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FISH AND INVERTEBRATES OF REVETMENTS AND OTHER HABITATS IN THE WILLAMETTE RIVER, OREGON

by

Randy C. Hjort, Patrick L. Hulett,
Larry D. LaBolle, Hiram W. Li

Oregon Cooperative Fishery Research Unit
Oregon State University
Corvallis, Oregon 97331

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In this study, physical and biological parameters were compared at revetments and other aquatic habitats in the Willamette River below Salem, Oregon. The purpose was to determine if revetments affect the distribution and abundance of fishes and invertebrates, and to examine relationships between the physical parameters and the biological community. Sampling sites included two revetments, two natural banks, two side channels, and an abandoned channel. The study was conducted in 1982 at two flow levels. Sampling periods were June

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when flows were moderate (283-425 m^3/sec) and August when flows were low (221-238 m^3/sec). The physical parameters included water quality indices (temperature, dissolved oxygen, pH, redox potential, turbidity, and conductivity), water velocity, and sediment analysis. The biological parameters were fish and invertebrate densities and fish weight.

During each study period, water quality indices were similar at all stations except for those in the abandoned channel, which was generally higher in water temperatures and conductivities and more variable in dissolved oxygen. Water temperatures and turbidities were higher during the August sampling period compared to June. Water current velocities were highest at the natural bank sites followed by the revetments and secondary channels. The abandoned channel had little or no water flowing through it.

Bottom types included large rocks at the revetments, silt and gravel mix in the abandoned channel, coarse gravel or sand at Five Island natural bank and the secondary channels depending on the water velocity, and silt and clay at Candiani natural bank where there was a severe erosion problem.

The species compositions of fishes and invertebrates were different among the habitats. Squawfish were the most abundant fish at the revetments and at Five Island secondary channel. Largescale suckers were the most abundant at Candiani natural bank, Candiani secondary channel, and the abandoned channel, and leopard dace were the most abundant at Five Island natural bank. Anisogammarus was the most abundant invertebrate at the revetments, while Oligochaetes were the most abundant at Candiani natural bank, Five Island secondary channel, and the abandoned channel. Chironomids were the most abundant invertebrate at Five Island natural bank and Candiani secondary channel. The densities of fish and invertebrates were generally highest at the revetments. The densities of fish were lowest in the secondary channels, and the densities of invertebrates were lowest at Candiani natural bank. The number of species and the species diversity were similar among the sampling sites. The total fish weight was highest at the abandoned channel, followed by Candiani secondary channel, Candiani natural bank, and the revetments.

Characteristics of the revetments include higher densities of fish and invertebrates; however, the species compositions at the revetments were different than those at the other habitats. Revetments offer stability of substrate and protective cover for organisms during high flows.

PREFACE

The study described in this report was conducted by the Oregon Cooperative Fishery Research Unit (OCFRU) at Oregon State University (OSU), Corvallis, Oregon, for the U. S. Army Engineer Waterways Experiment Station (WES) under Intra-Army Order No. WESRF-82-106. This study is part of the Environmental and Water Quality Operational Studies (EWQOS), sponsored by the Office, Chief of Engineers (OCE), and assigned to WES under the management of the Environmental Laboratory. The OCE Technical Monitors for EWQOS were Dr. John Bushman, Mr. Earl Eiker, and Mr. James L. Gottesman.

This report presents the results of a study designed to determine the impact of stone revetments on the distribution and abundance of fishes and benthic invertebrates of the lower Willamette River between river miles 58 and 66. The study periods were in June and August of 1982.

The report was prepared by Mr. Randy C. Hjort, Mr. Patrick L. Hulett, Mr. Larry D. LaBolle, and Dr. Hiram W. Li of OCFRU. Mr. Dave Nelson (WES) administered the study, and Dr. C. H. Pennington (WES) developed the sampling scheme. Mr. Dale McCullough (OSU) designed the sampling gear for the benthic invertebrates and helped collect field samples. Dr. Charles Hawkins (OSU) and Mr. Randy Wildman (OCFRU) identified the benthic invertebrates. Dr. Peter Klingeman and Mr. Jeffrey Pike of the Water Resources Research Institute (OSU) analyzed the sediment samples. Program Manager of EWQOS was Dr. J. L. Mahloch (WES).

Special appreciation is expressed to Ms. Adrian Hunter who typed the manuscript, Miss LaVon Mauer who prepared the tables, and Dr. Stan Gregory who helped analyze the distribution of benthic invertebrates.

Commander and Director of WES during the study and preparation of this report was COL Tilford C. Creel, CE. The Technical Director was Mr. F. R. Brown.

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CONTENTS

FISH AND INVERTEBRATES OF REVETMENTS AND OTHER HABITATS IN THE WILLAMETTE RIVER, OREGON

PART I: INTRODUCTION

1. Stone revetments have been used extensively on the Willamette River to stabilize the streambanks and channels. The revetments are placed at eroding banks to prevent channel changes and the loss of land, thus protecting farmland, buildings, roads, and utilities. The first revetment on the Willamette River was installed in 1888, and since that time a variety of bank stabilization techniques have been tried (Thornber 1965; Thornber and Bubenik, undated). The Army Corps of Engineers has been responsible for the construction and the evaluation of the revetments on the Willamette River (U. S. Army Corps of Engineers 1975) and has sponsored studies to evaluate alternatives and supplements to riprap revetments (Klingeman and Bradley 1976; Bierly and Assoc. 1980).

2. Extensive bibliographies have been compiled for streambank protection techniques (Keown et al. 1977) and their effects (Stern and Stern 1980). Information on riprap-type revetments and their biological impact is more limited, and the conclusions vary among stream systems. The physical effects of revetments on streams range from little apparent impact (Bulkley et al. 1976) to actually changing the stream morphology and reducing habitat diversity for aquatic organisms (Johnson et al. 1974; Funk and Robinson 1974). Other effects include reduction of the riparian vegetation, which affects both terrestrial and aquatic organisms (U. S. Fish and Wildlife Service 1976) and possible degradation of the streambed (Klingeman 1973). Revetments are believed to benefit invertebrates by stabilizing bank habitat so that invertebrates can become established (Johnson et al. 1974; Solomon et al. 1975; Menzel and Fierstine 1976); however, in some cases, revetted sections of stream have lower fish production or standing crops than nonrevetted sections (Bianchi and Marcoux 1975; Peters and Alvord 1963).

3. The Willamette River has experienced a dramatic change during the past 20 years. An extensive cleanup program (Gleeson 1972; Starbird 1972; Council on Environmental Quality 1973), an upstream reservoir system (Shearman 1976), and a proposed Willamette River Greenway System have changed the purpose of the river from a conveyer of industrial and municipal sewage

(Gleeson and Merryfield 1936; Westgarth and Northcraft 1964; Britton 1965) to a recreational and environmental asset (Willamette Basin Task Force 1969; Hansen 1977; Deval 1977).

4. The number and size of the Willamette River revetments impact the physical and biological characteristics of the streambanks. Physical impacts include changes in shoreline substrate type, shoreline gradient, and water velocity. These physical changes may affect the distribution and abundance of fishes and benthic invertebrates in the Willamette River.

5. This study was designed to address the following objectives regarding the physical and biological impacts of revetments.

- a. To determine whether there are differences in the distribution and abundance of fishes and benthic invertebrates between revetted and nonrevetted banks on the Willamette River below Salem, Oregon.
- b. To quantitatively describe certain physical characteristics of revetted and nonrevetted banks of the river.
- c. To correlate changes in invertebrate and fish densities with differences in physical habitat.
- d. To compare the composition of different functional groups of fishes and invertebrates in different environmental settings.

PART II: METHODS AND MATERIALS

Sampling Periods and Locations

6. This study was conducted on the Willamette River at two different flow levels: during 8-18 June when the flows were at moderate levels (283-425 m^3/sec) and during 16-25 August when the flows were lower (221-238 m^3/sec).

7. Seven locations between river miles 58 and 66 of the Willamette River, Oregon were sampled (Figure 1). These locations were distributed among four habitat types: two revetted banks--banks on the outside bends of the main river channel stabilized by stone (riprap) revetments (Figures 2,3); two natural banks--nonrevetted banks of the main channel (Figure 5)--one actively eroding, one apparently stable (Figure 4); two secondary channels--shallow, narrow channels that run parallel to the main river channel (Figures 4,5); and one abandoned channel--an old channel, still connected to the main river channel but carrying no flow during the study period (Figure 6). In each location four stations were marked along the shoreline at 152-m intervals. These stations were used to determine sites for fish sampling, substrate sampling, and measurement of chemical and physical water parameters.

Sampling Techniques

Fish

8. A boat electroshocker and hoopnets were used to sample the fish from each location. The electroshocking boat pulsed direct current at 120 cycles/second, through boom-mounted anodes with the boat hull serving as the cathode. Traveling downstream, samples were taken close to shore along three 152-m transects between the four stations at each of the seven locations. Thus, 21 transects were sampled for each of the two sampling periods. Data obtained for each transect were recorded separately. The amperage, voltage, and pulse width were standardized on a test run and the same settings were used for all locations where conductivities were similar. The voltage was decreased in areas of high conductivity and increased in areas of low conductivity to maximize the amperage.

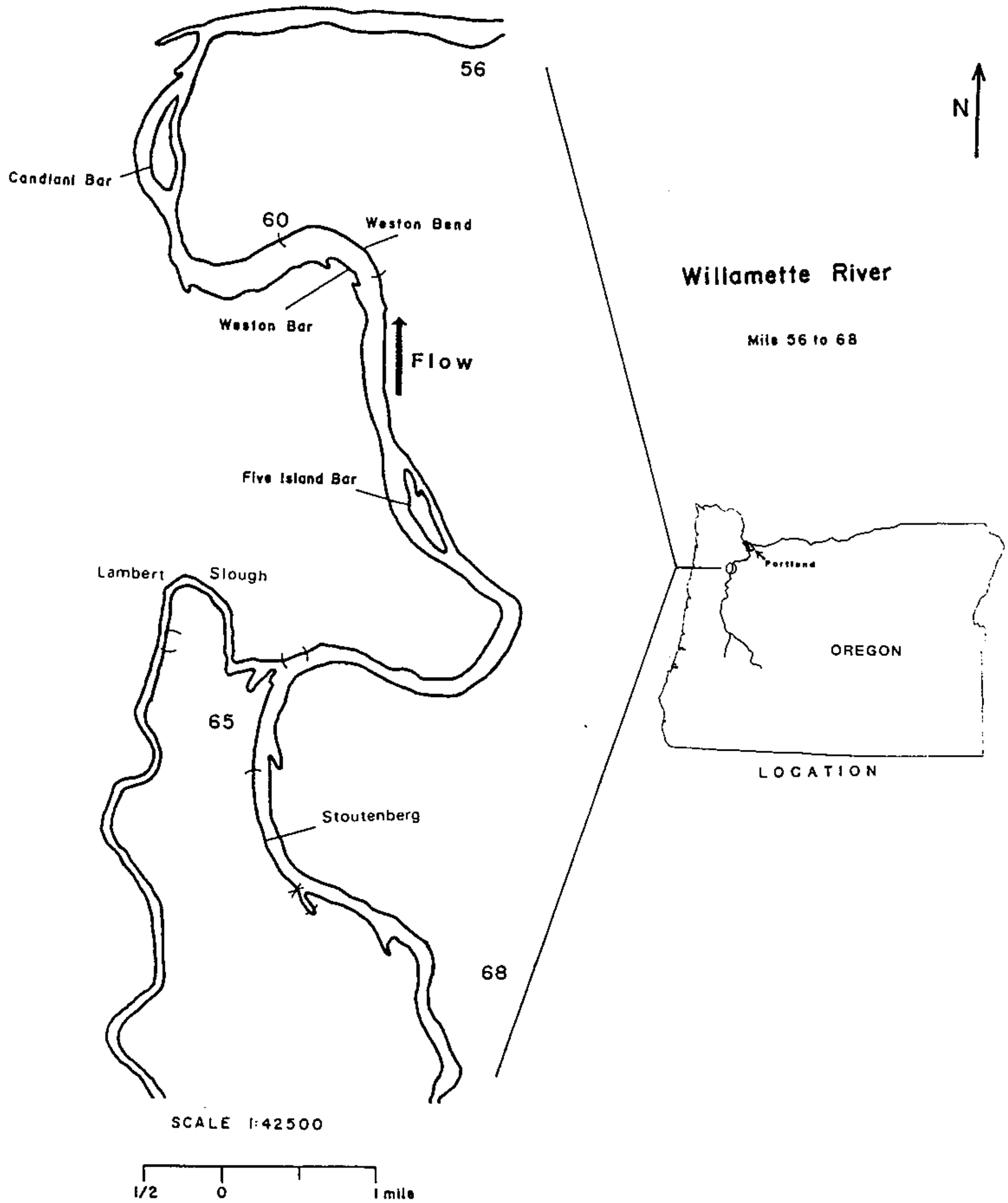

Figure 1. Map illustrating the sampling locations within the study area on the Willamette River, Oregon

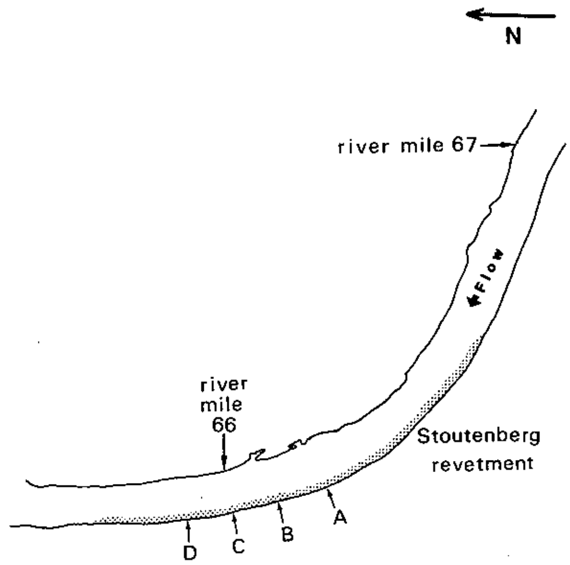

Figure 2. Map illustrating the Stoutenberg revetment sampling location. (Stippling indicates revetted bank; letters A-D represent the sampling stations)

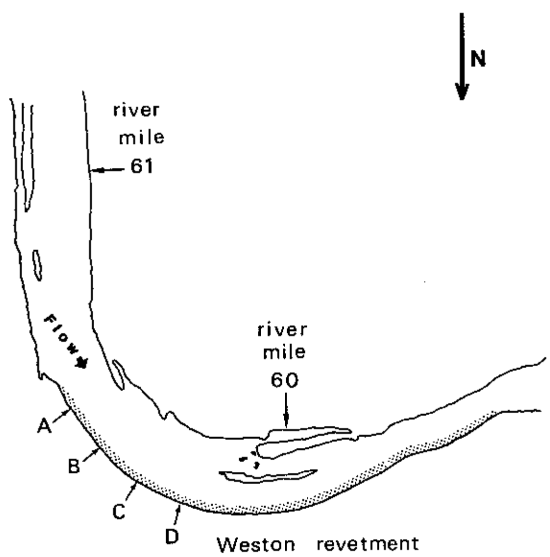

Figure 3. Map illustrating the Weston revetment sampling location. (Stippling indicates revetted bank; letters A-D represent the sampling stations)

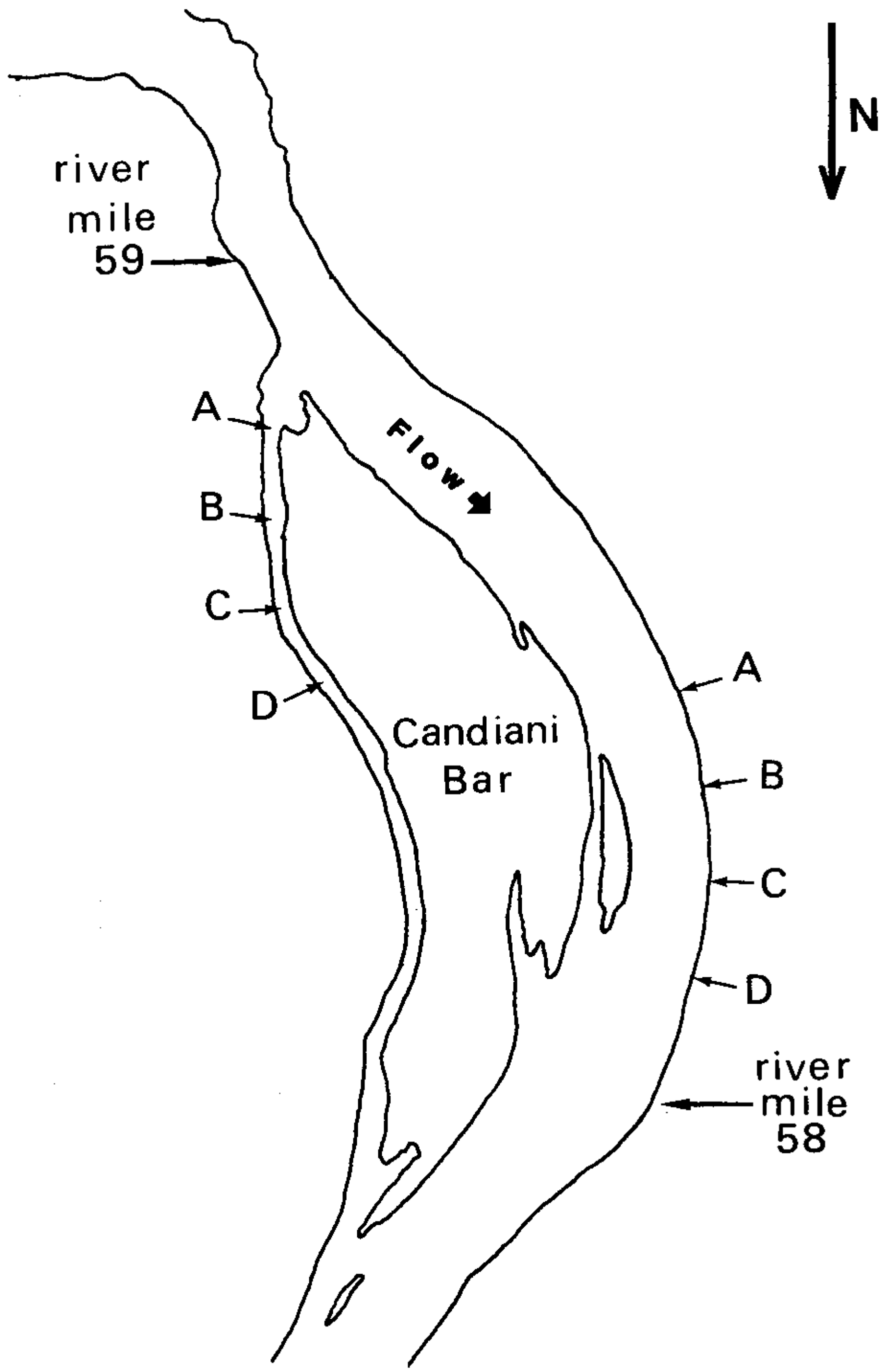

Figure 4. Map illustrating the Candiani Bar natural bank (right) and secondary channel (left) sampling locations. (Letters A-D indicate the sampling stations)

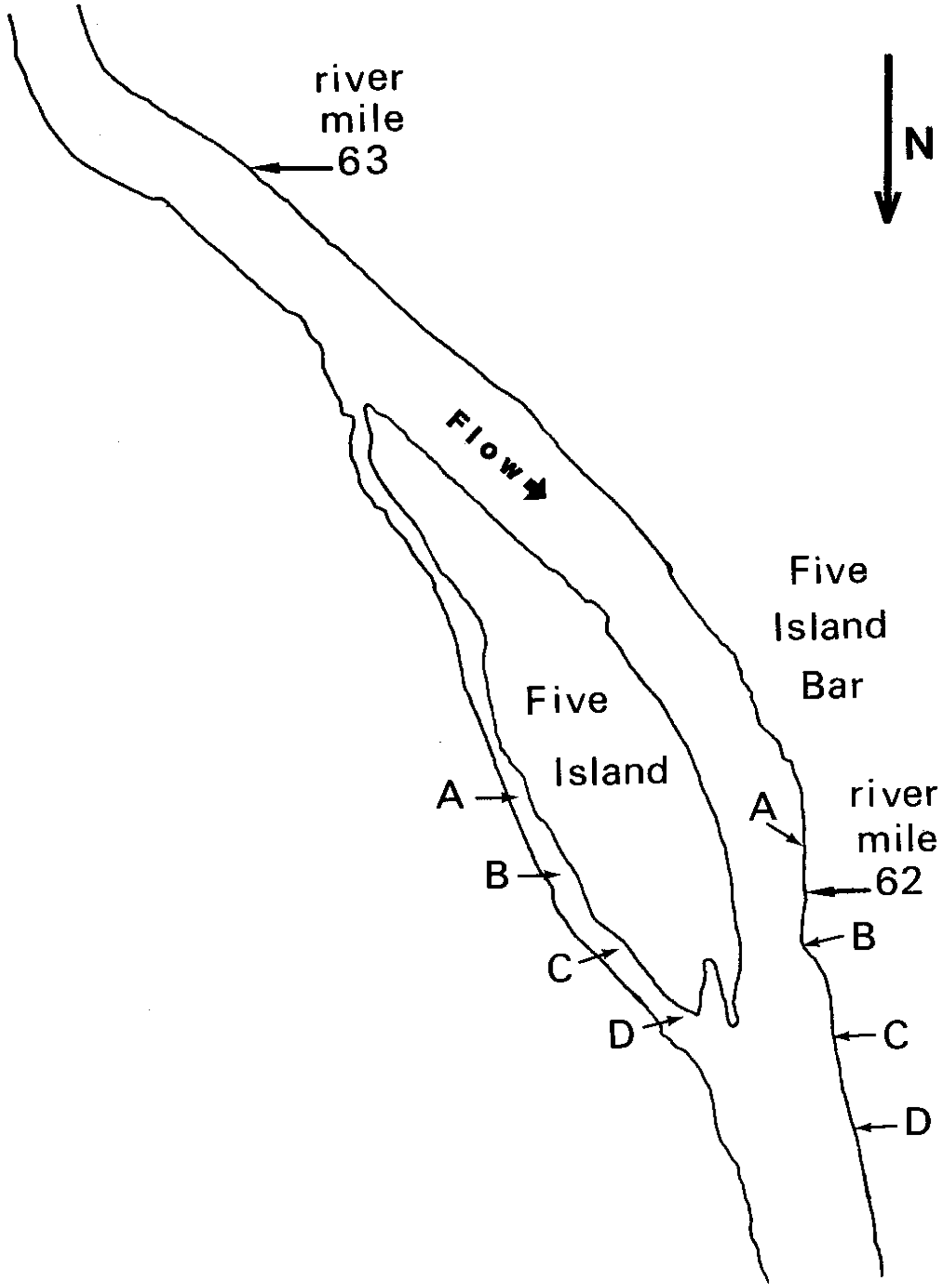

Figure 5. Map illustrating the Five Island Bar natural bank (right) and secondary channel (left) sampling locations. (Letters A-D indicate the sampling stations)

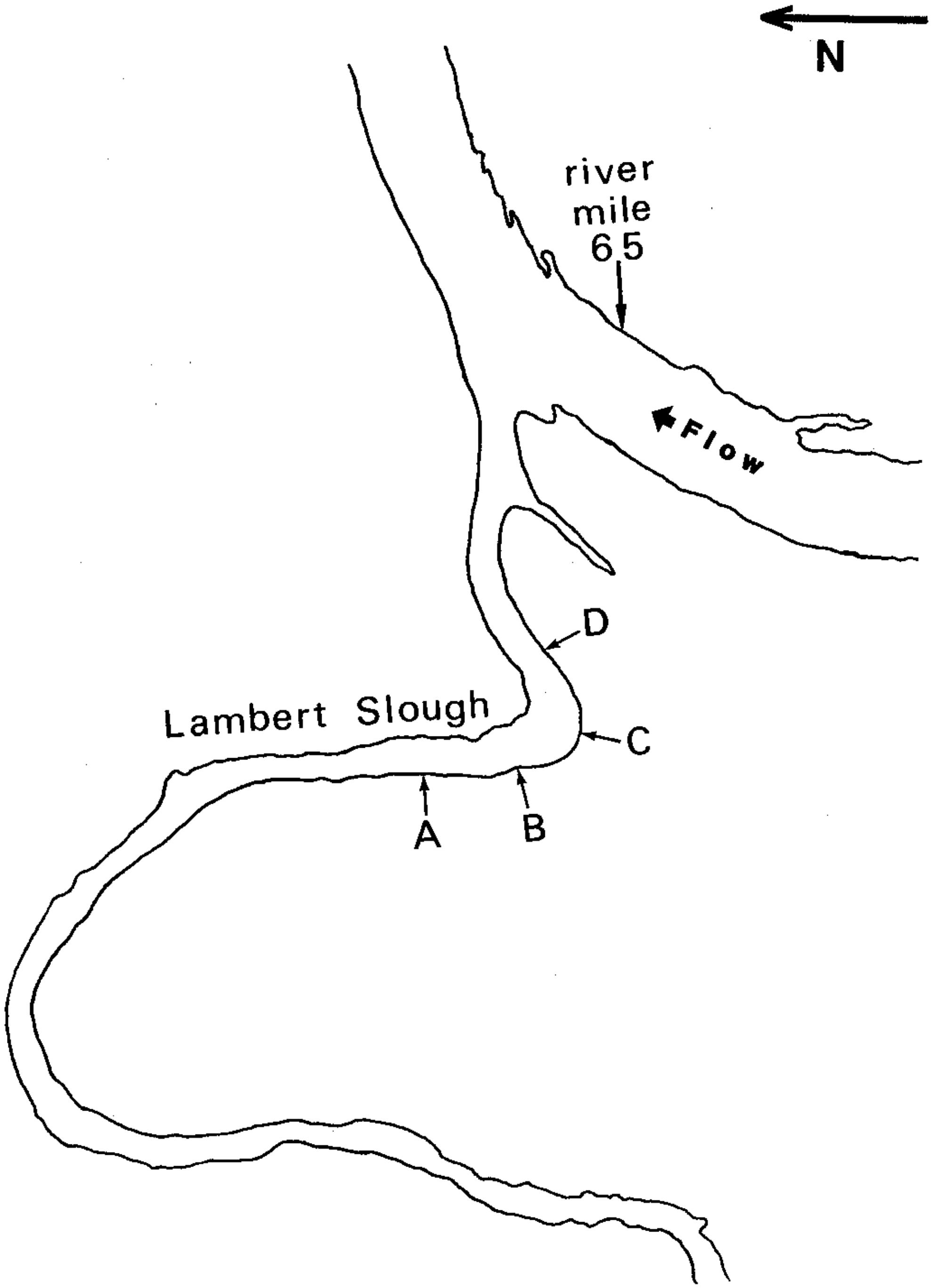

Figure 6. Map illustrating the Lambert Slough abandoned channel sampling location. (Letters A-D indicate the sampling stations)

9. The hoopnets, constructed of 2.5-cm-square mesh, were 4.6-m long with seven 0.9-m hoops and two throats, located at hoops 2 and 4. The nets were set, unbaited, facing downstream at each of the four stations in each location for two consecutive 24-hour periods. Thus, 56 hoopnet sets were sampled in each of the two sampling periods.

10. For each shocking transect and hoopnet set, each fish was identified to species using keys prepared by Bond (1973) or Wydoski and Whitney (1979). Total lengths (millimetres) and weights (grams) were recorded. Specimens which were difficult to identify were preserved for later identification.

Benthic Invertebrates

11. The benthic invertebrates were sampled at each revetted station midway between the waterline and the toe of the revetment, and at a similar position in the natural habitats. One of two methods was employed to collect the samples, depending on the substrate size and water velocity at each station. A glove-box sampler (Figure 7) was placed on the bottom, and the substrate was scooped into an attached collection bag at all nonrevetted sites with moderate or high water velocity. At stations with low water velocity, the smaller substrate was pumped to the surface by a venturi-type dredge and sieved through a 0.3-mm mesh. At the revetted stations, the surface and crevices of the substrate were vacuumed and the smaller riprap material to be cleaned of organisms at the surface was removed. Two replicates were collected to a depth of 27 cm at each station and combined into one sample. The total area of the two replicates equaled a 0.5- x 0.5-m quadrate. The samples were preserved in 10% formalin, and the date, time, depth, water velocity, location, and station were recorded.

12. Before sorting, the samples were sieved through 0.5-mm mesh, transferred to 70% ethanol, stained with Rose Bengal solution, and subsampled using settling tubes as described by Mundie (1971). One of two subsamplers was used, depending on the volume of the samples. For large samples, a 19-l bucket (277-mm diameter) was used with 200 test tubes, each with a mouth area of 1/365 of the bucket's total cross-sectional area. For small samples, a 120-mm-diam container, with 24 test tubes each with a mouth area of 1/50 of the cross-sectional area of the container, was used. The organisms were sorted using variable-power dissecting scopes (8-40x). Identification was to the generic level.

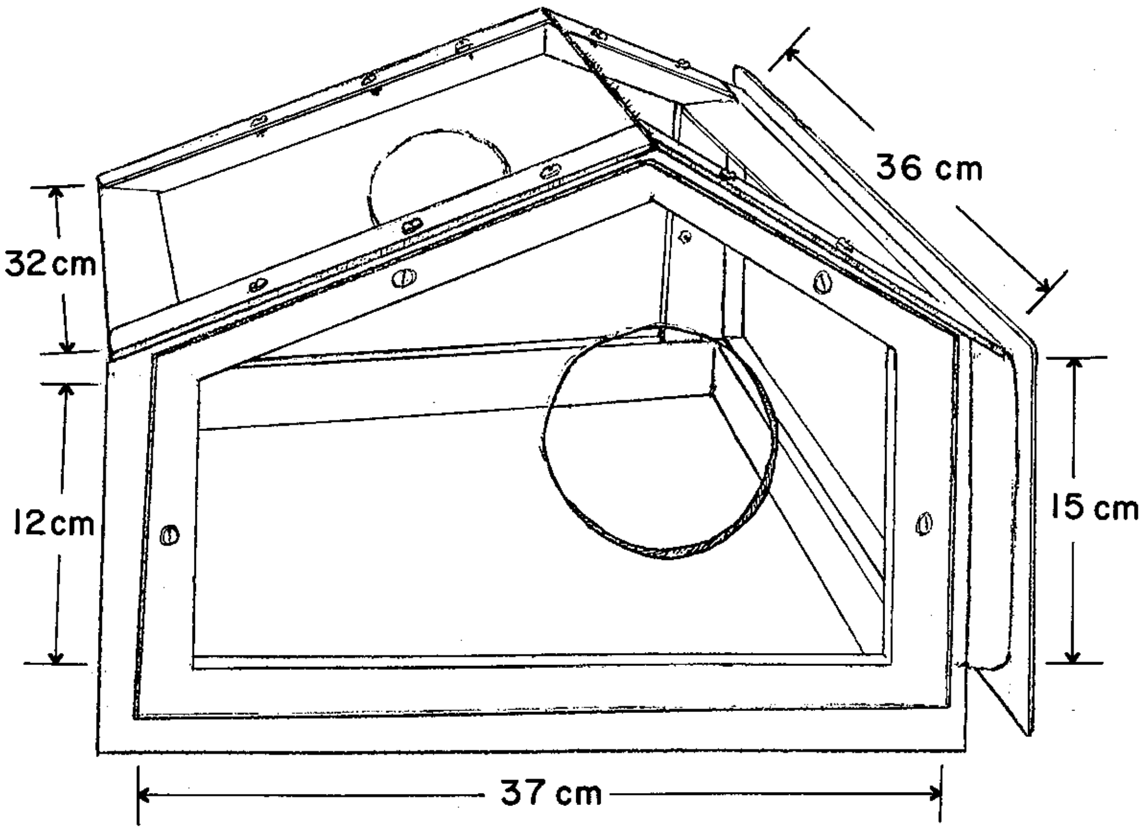

Figure 7. Design of glove-box sampler for collection of benthic invertebrates in flowing water. Frame is of heavy-gage steel bars and and angle iron. Plexiglass panels cover top and side surfaces. Bottom, front, and rear are open. A bag attaches over the rear opening (15 x 36 cm), collecting benthos carried by current that enters through the front opening (12 x 32 cm). Reaching through arm ports (10-cm-diam) in side panels, operator scoops substrate into collection bag from area defined by bottom opening (12 cm wide in front, 37 cm long and 15 cm wide in rear = 1/8 m^2), digging to desired sample depth

Physical and Chemical

13. The stations at which samples for identifying sediment type were taken corresponded with those of the benthic invertebrate samples. Sediment samples were collected only during the first sampling period. The samples were analyzed for grain size according to Engineer Manual 1100-2-1906 (Department of the Army 1970).

14. The physical and chemical water parameters were measured in each habitat at dawn and dusk of the first and last sampling days for each sampling period. A calibrated Hydrolab multiparameter, in situ water analysis system (Model No. 8100) was used to measure the following: a) temperature in °C to the nearest tenth; b) dissolved oxygen in milligrams/liter; c) acidity in pH units to the nearest tenth; d) specific conductance in micromhos/square centimetre at 25°C to the nearest micromho; and e) redox potential in millivolts. An Endeco current meter was calibrated and used to determine the water velocity. Readings were recorded at 1 m below the surface, mid-depth, and 1 m above the substrate for stations with a depth greater than 3 m. For shallower stations, the readings were taken at shorter depth intervals or at a single depth. The latter case applied to all stations in August when water levels were lower.

15. Turbidity measurements were taken with a Hach laboratory turbidimeter, and the date, time, and water depth at each set of data were recorded. In addition, the water velocity and depth were recorded at each station for the hoopnet and benthic invertebrate samples. To estimate the average water velocity for each 152-m electroshocking transect, the water velocity values at the start and finish of each transect were averaged.

Statistical Analysis

16. Analysis of covariance on the abundance and weight per unit effort of each fish species and the abundance of benthic invertebrates was used to determine if significant differences existed among the locations. The 5% significance level was used in all analyses. The units of effort were 152-m transects for the electroshocker, 24-hour soak time for the hoopnets, and the 0.5-m-square sample for the benthic invertebrates.

17. Two important variates distinguishing locations were bottom type and water velocity. Water velocity was highly variable within locations, whereas substrate composition was relatively homogeneous. The analysis of covariance described the influence of location (and therefore substrate composition) and water velocity on the abundance/weight of fishes/invertebrates.

18. Three types of tests were performed using the analysis of covariance: a) a one-way analysis of variance to determine whether or not differences in abundance or weight of fishes or invertebrates significantly varied among locations; b) a correlation analysis between abundances/weights of fishes/invertebrates, and the covariate water velocity; and c) another one-way analysis of variance, this time using the abundances/weights of fishes/invertebrates that were adjusted for water velocity before comparisons were made among locations.

19. To determine if there were statistically significant differences between the sampling periods for abundance and weight, a completely randomized block analysis of variance, at the 5% significance level, was used. The blocks were the locations and the treatments were the sampling periods. Each gear type was analyzed separately and the differences were examined using Duncan's new multiple range test. The fish catch per unit efforts were transformed to ensure normality by using $\log_{10}(x+1)$ (Green 1979).

20. The Jaccard similarity coefficient was used to compare the similarity of fish species composition and the similarity of the benthic invertebrate samples among the different locations for each sampling period. The fish and benthic invertebrate diversities at each habitat type and for each sampling period were compared using the Shannon diversity index: $H' = -\Sigma p_i \log_{10} p_i$ where p_i is the proportion of each species or taxa. Electroshocking data were used to derive estimates of species composition and the Shannon diversity index (H'), while data from both collecting gears were used separately for statistical tests for differences in catch among locations. Data from both gears were combined to determine the Jaccard similarity index and species richness at each location. The fish catch and weight data from electroshocking and the hoopnets are presented in Appendix A, and the benthic invertebrate data are presented in Appendix B.

PART III: RESULTS

Sediments

Revetments

21. The Stoutenberg and Weston revetments were both constructed of irregularly shaped rocks, commonly called riprap, which were approximately 0.1 to 1.0 m in diameter. Numerous interstitial spaces were present. The bottom sediments in these habitats were not analyzed because most of the substrate was the large rock and there was very little sediment in the interstitial spaces.

Natural Banks

22. The substrates were similar among different stations of the natural bank at Five Island. The sediments were composed primarily of coarse and fine gravel and small amounts of fine sand (Appendix C). Station C had the lowest proportion of fine sand of the four stations because of its higher water velocity. Five Island natural bank appeared to be the most stable of the two natural bank locations in the study, with little or no erosion taking place during the study period.

23. The natural bank at Candiani Bar had a steep soil bank that eroded extensively before and during the study period. As a result, sediment samples consisted of fine sands and silt or clay (Appendix C). Indications that large portions of the bank were sloughing into the river were observed (localized high turbidity in the river, freshly exposed soil on the bank, and clumps of terrestrial grasses in the water).

Secondary Channels

24. Substrate samples from seven of the eight stations in the two secondary channels were 60-85% coarse and fine gravels, the remainder consisting of fine sand (Appendix C). The exception to this pattern was station D at Five Island, the substrate of which was comprised of 40% gravels and 60% fine sands. The water depth at this station was 1 to 2 m and there was little or no water current at the time of the study.

Abandoned Channel

25. The four stations in Lambert Slough were of two distinct sediment types. Sediments of the two stations farthest from the main channel, stations A and B, were fine sands and silt or clay (Appendix C). The highest proportion of organic material was found at these two stations. Sediments of the two stations closest to the river were dominated by coarse and fine gravels with some fine sands.

Water Quality

Revetments, Natural Banks, and Secondary Channels

26. Measurements of water quality were similar among locations in the main channel and secondary channels during the course of the study (Tables 1 and 2). Major trends include an increase in temperature, dissolved oxygen and pH from dawn to dusk, and an increase in water temperature from the beginning of the sampling period to the end. Water temperature and turbidity both increased from June to August. The parameters of water quality in June ranged as follows: temperature (14.0-20.3° C), dissolved oxygen (7.9-10.8 mg/l), conductivity (69-75 μmhos), pH (6.7-7.7), oxidation-reduction potential (283-318 mv), and turbidity (0.8-1.7 NTU). In August the values were: temperature (17.7-21.5° C), dissolved oxygen (7.5-9.7 mg/l), conductivity (76-83 μmhos), pH (6.7-7.4), oxidation-reduction potential (220-323 mv), and turbidity (0.9-3.8 NTU).

27. Water current velocities ranged from 0 to 123 cm/sec (Table 3). The highest average velocities were recorded at the natural bank locations, while the revetments and secondary channels were lower. Both secondary channels had a station with no current because they were located at deep pools. Average velocities decreased from June to August at all locations except the natural bank at Five Island and at the Candiani secondary channel where the velocities increased. The increase in August was due to a change in the sampling location, as lower water levels necessitated shifting the sampling site closer to the center of the stream.

Table 1. Physical variables recorded at station B of seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 8-18, 1982. Variables were recorded at three depths in Lambert Slough: 1 meter below the surface (1), midway between the surface and the bottom (2), and 1 meter above the bottom (3).

			Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel		
									Lambert Slough		
Variable (unit)	Date	Time	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	1	2	3
Sample Depth (m)	6-8	Dawn	0.8	1.1	0.5	1.1	0.5	0.5	0.6	1.2	-
		Dusk	0.9	1.1	0.5	0.9	0.5	0.5	1.0	2.0	3.0
	6-18	Dawn	0.6	0.8	0.5	1.2	0.5	0.8	0.9	1.4	2.4
		Dusk	0.6	0.9	0.5	0.9	0.5	0.8	0.9	1.4	2.1
Temperature (°C)	6-8	Dawn	14.2	14.1	14.0	14.2	14.0	14.1	15.7	15.1	-
		Dusk	15.0	15.0	15.0	15.0	15.1	15.0	15.3	14.7	14.4
	6-18	Dawn	18.0	18.2	18.4	18.4	18.2	18.4	19.5	17.6	17.3
		Dusk	20.3	20.2	20.2	20.2	20.2	20.2	21.0	19.0	17.7
Dissolved Oxygen (mg/l)	6-8	Dawn	9.5	9.8	10.1	9.6	9.8	9.9	10.1	10.4	-
		Dusk	10.7	10.5	10.6	10.7	10.6	10.8	10.6	7.6	4.6
	6-18	Dawn	8.4	7.9	8.0	8.4	8.3	8.2	10.5	10.0	9.8
		Dusk	8.9	8.7	8.6	8.9	8.9	9.1	15.1	11.8	10.9
Conductivity (μmho)	6-8	Dawn	72	74	74	75	73	74	132	130	-
		Dusk	73	75	74	74	74	74	123	109	105
	6-18	Dawn	70	70	71	71	70	70	115	120	124
		Dusk	69	70	70	70	70	69	118	95	123
pH	6-8	Dawn	7.2	7.1	7.2	7.2	7.2	7.2	6.8	6.6	-
		Dusk	7.7	7.6	7.6	7.6	7.6	7.6	6.8	6.6	6.4
	6-18	Dawn	6.8	6.8	6.7	6.7	6.8	6.7	6.9	6.6	6.5
		Dusk	7.2	7.1	7.0	7.1	7.2	7.2	7.1	7.4	6.6
Oxidation-Reduction Potential (mv)	6-8	Dawn	283	315	301	314	313	301	266	220	-
		Dusk	291	304	318	300	316	297	333	335	339
	6-18	Dawn	295	305	303	312	304	313	312	319	316
		Dusk	288	289	291	288	284	285	287	288	313
Current Velocity (cm/sec)	6-8	Dawn	108	83	108	103	77	83	0	0	-
		Dusk	93	82	83	139	98	103	0	0	0
	6-18	Dawn	72	62	62	93	83	103	0	0	0
		Dusk	57	57	72	93	82	93	0	0	0
Turbidity (NTU)	6-8	Dawn	0.8	1.3	1.2	1.3	0.8	1.1	1.4	-	-
		Dusk	1.2	1.3	1.2	1.3	1.3	1.2	1.8	-	-
	6-18	Dawn	1.3	1.3	1.3	1.5	1.3	1.4	1.4	-	-
		Dusk	1.4	1.3	1.5	1.7	1.4	1.2	1.9	-	-

Table 2. Physical variables recorded at station B of seven locations between river miles 58 and 66 on the Willamette River, Oregon, August 16-25, 1982.

Variable (unit)	Date	Time	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
			Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Sample Depth (m)	8-16	Dawn	0.9	0.9	0.4	0.9	0.6	0.6	0.9
		Dusk	0.9	0.9	0.6	0.9	0.6	0.6	0.9
	8-25	Dawn	0.6	0.9	0.5	0.9	0.9	0.6	0.9
		Dusk	0.9	0.9	0.6	0.9	0.9	0.6	0.9
Temperature (°C)	8-16	Dawn	17.7	17.9	17.8	18.1	17.8	18.0	19.4
		Dusk	19.5	19.5	19.5	19.5	19.5	19.6	22.2
	8-25	Dawn	19.7	19.8	19.7	20.0	19.8	20.0	23.1
		Dusk	21.5	21.3	21.3	21.2	21.3	21.3	23.2
Dissolved Oxygen (mg/l)	8-16	Dawn	8.3	8.2	8.4	8.5	8.6	8.3	8.2
		Dusk	8.8	9.1	9.4	9.3	9.6	9.7	9.6
	8-25	Dawn	8.4	7.9	8.2	7.7	8.2	7.5	9.0
		Dusk	8.7	8.6	8.8	9.2	8.7	8.6	9.8
Conductivity (umho)	8-16	Dawn	80	81	80	81	79	80	125
		Dusk	81	82	82	82	83	82	130
	8-25	Dawn	76	76	76	76	76	76	118
		Dusk	78	78	78	77	77	77	116
pH	8-16	Dawn	6.8	6.8	6.7	6.8	6.8	6.8	6.6
		Dusk	7.3	7.2	7.3	7.3	7.3	7.3	7.0
	8-25	Dawn	6.9	6.8	6.8	6.7	6.8	6.8	6.9
		Dusk	7.4	7.3	7.3	7.3	7.4	7.3	7.3
Oxidation-Reduction Potential (mv)	8-16	Dawn	291	322	275	323	302	321	274
		Dusk	277	304	294	302	300	302	295
	8-25	Dawn	220	293	320	283	315	311	315
		Dusk	271	317	291	289	312	313	300
Current Velocity (cm/sec)	8-16	Dawn	41	36	62	57	118	77	0
		Dusk	46	26	98	51	118	77	0
	8-25	Dawn	36	36	51	51	108	77	0
		Dusk	46	31	57	51	118	77	0
Turbidity (NTU)	8-16	Dawn	1.3	1.8	1.8	2.2	1.8	1.5	2.7
		Dusk	1.8	1.7	2.1	1.4	2.2	1.7	1.8
	8-25	Dawn	1.3	1.3	1.6	1.4	1.5	3.8	1.6
		Dusk	0.9	2.1	1.9	1.7	1.7	1.8	1.7

Table 3. Water velocity in cm/sec and depth in meters recorded at 28 benthic and fish netting stations in seven locations between river miles 58 and 66 of the Willamette River, Oregon, June and August 1982.

	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
Sampling period	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
June																												
Velocity	41	67	51	67	41	62	67	72	51	67	123	62	93	77	93	72	83	83	57	0	62	46	0	46	0	0	0	0
Depth	1.8	1.5	2.3	1.8	1.2	2.3	2.3	1.8	1.0	0.9	0.9	0.9	1.5	1.2	1.3	1.3	1.0	0.9	2.0	1.4	1.0	1.0	2.0	0.7	3.0	1.8	1.8	1.5
August																												
Velocity	26	36	36	46	26	41	31	46	82	93	83	77	46	46	67	77	51	57	41	0	41	46	41	123	0	0	0	0
Depth	1.8	0.9	1.2	1.5	1.8	1.8	1.2	1.2	0.9	0.6	0.4	0.6	1.8	1.5	1.2	0.9	1.2	0.9	1.8	1.2	0.6	0.6	1.9	0.6	2.4	1.5	1.8	1.5
AVERAGES																												
June																												
Velocity		57				62				77				82				57				41				0		
Depth		1.9				1.9				0.9				1.3				1.3				1.2				2.0		
August																												
Velocity		36				36				83				62				36				62				0		
Depth		1.4				1.5				0.6				1.4				1.3				0.9				1.8		

Abandoned Channel

28. Primary differences in the water quality data occurred between Lambert Slough and the other locations, all of which were more lotic in nature (Tables 1 and 2). Temperatures in Lambert Slough were generally higher than in the main river, ranging from 19.4-23.2° C in August. As expected, temperatures increased from dawn to dusk from the first day of sampling to the last, from June to August, and (in June) from the bottom to the surface. Dissolved oxygen increased between dawn and dusk, and from the bottom to the surface, but readings were higher in June than in August. Values ranged from 15.1 mg/l to a low of 4.6 mg/l recorded on the bottom in June. The latter value was the only indication of dissolved oxygen being a limiting factor in any of the locations. The 15.1 mg/l value was the highest dissolved oxygen level recorded during the study. Excluding these two values, dissolved oxygen levels in Lambert Slough were comparable to those of the other locations. Conductivity levels were much higher in Lambert Slough, ranging from 95 to 132 μmhos, compared to 69 to 83 μmhos in the main river. The pH, oxidation-reduction potential, and turbidity readings were similar to those from locations associated with high flow, ranging in value from 6.4-7.4, 220-335 mv, and 1.4-2.7 NTU, respectively.

Fish

Revetments

29. Stoutenberg. A total of 10 species were collected at this location (Figure 8), including 291 individuals weighing a total of 24.4 kg collected with the electroshocker (Figure 9). This was the greatest number of individuals collected from any location. The most common species at Stoutenberg revetment were: northern squawfish (63%), prickly sculpin (12%), largescale sucker (9%), chiselmouth (6%), and redside shiner (6%) (Table 4).

30. Significantly greater catches using the electroshocker were recorded at Stoutenberg revetment than at other locations for the following species: northern squawfish and chiselmouth during June; prickly sculpin in August; and reticulate sculpin during both sampling periods (Table 5). Stoutenberg also had the greatest catch of chiselmouth by hoopnets in August (Table 6).

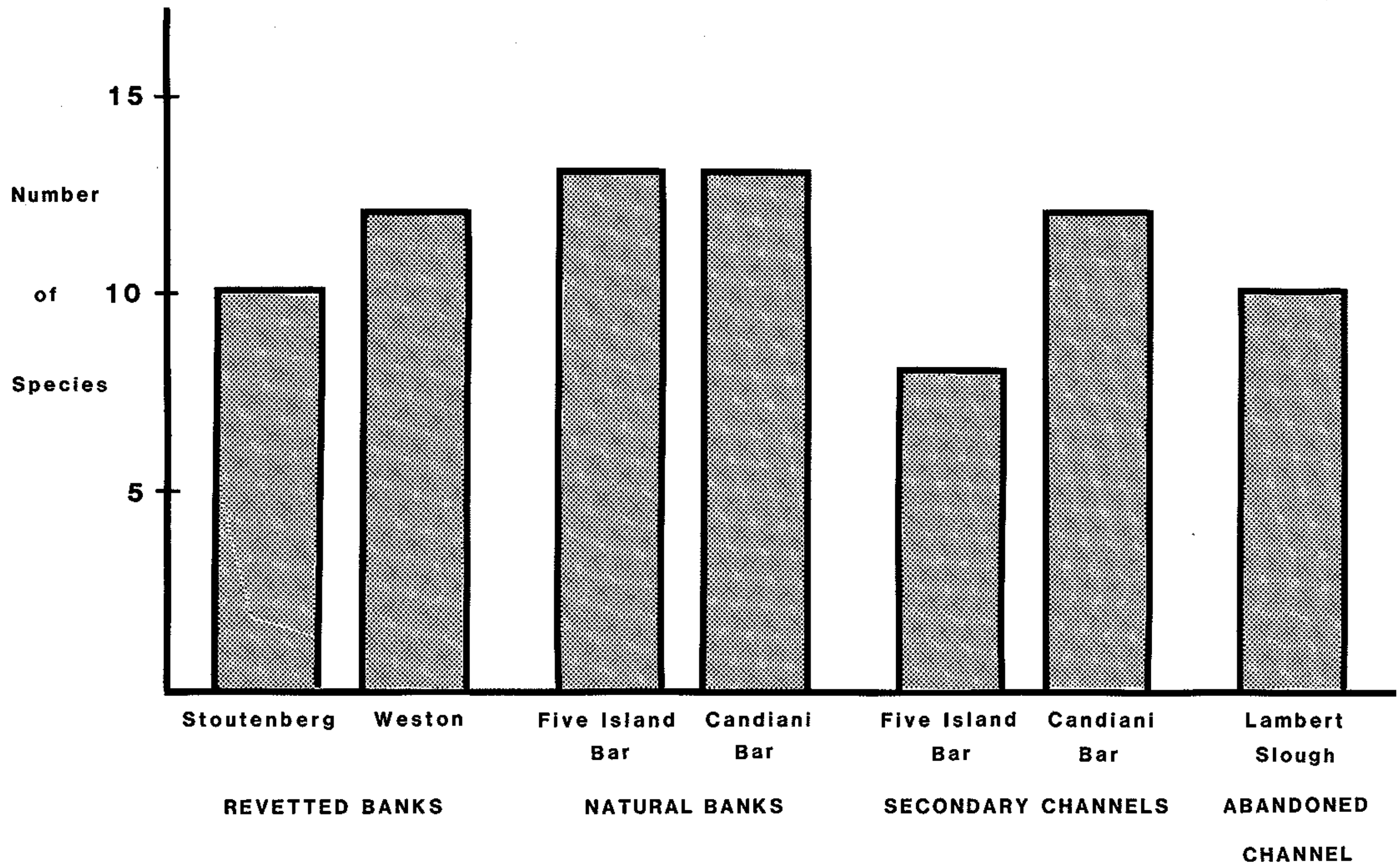

Figure 8. Numbers of species of fish collected by electroshocker and hoopnets from seven locations within four habitat types of the Willamette River during June and August 1982

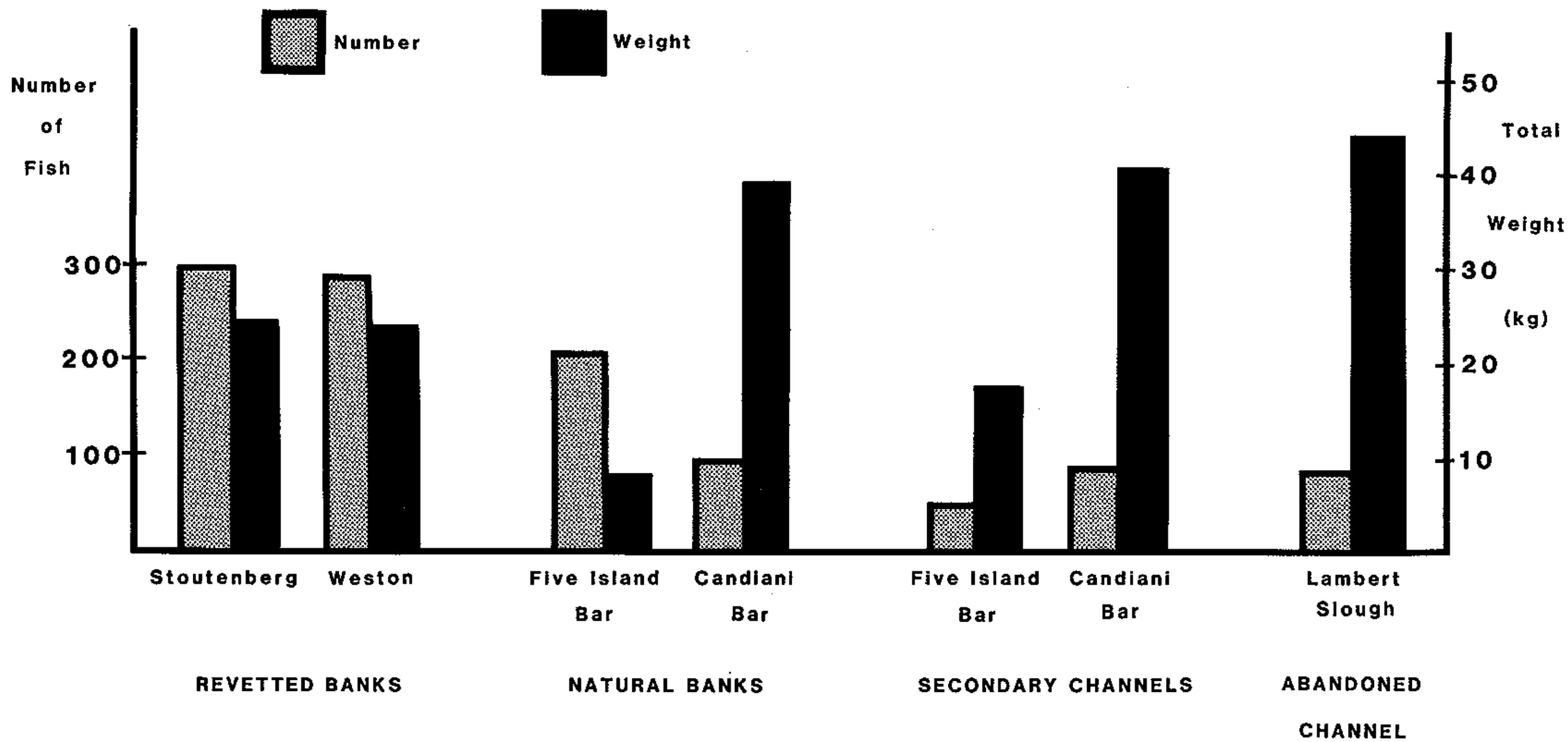

Figure 9. Total numbers and kilograms of fish collected by electroshocking seven locations within four habitat types of the Willamette River during June and August 1982

Table 4. Total species, total individuals, total weight (grams), and dominant species for June and August electroshocker catches, Willamette River, Oregon, 1982. Abbreviated forms of species names are are follows: SQUAW-northern squawfish, PSCULP-prickly sculpin, LSS-largescale sucker, CHIS-chiselmouth, RSS-redside shiner, LEOP-leopard dace, MS-mountain sucker, PEAM-peamouth, LMB-largemouth bass, and WCRAP-white crappie.

	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Total No. Species							
June	8	11	9	7	5	7	8
August	7	7	8	6	4	5	4
Total No. Individuals							
June	150	96	120	39	22	47	54
August	141	174	90	50	27	41	28
Total Weight							
June	17,372	11,725	4,101	20,169	9,052	23,374	29,523
August	7,013	11,948	3,773	18,794	8,427	17,244	14,504
% of Catch of Dominant Species							
Rank							
1	SQUAW 62.9	SQUAW 54.8	LEOP 35.2	LSS 51.7	SQUAW 44.9	LSS 53.4	LSS 61.0
2	PSCULP 11.7	PSCULP 10.9	SQUAW 24.8	SQUAW 33.7	LSS 36.0	SQUAW 21.6	LMB 20.7
3	LSS 8.9	CHIS 9.2	CHIS 11.0	RSS 4.5		PEAM 6.8	WCRAP 4.9
4	CHIS 5.8	RSS 8.9	MS 7.6			CHIS 5.7	SQUAW 6.1
5	RSS 5.8	LSS 8.5	LSS 7.1				

Table 5. Species average catch per transect and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for the Willamette River electroshocking catches at seven locations during two sampling periods. Location codes are as follows: ACS, Lambert Slough; NBC, Candiani natural bank; NBF, Five Island natural bank; PCC, Candiani secondary channel; PCF, Five Island secondary channel; RVN, Weston revetment; and RVT, Stoutenberg revetment. The F values are as follows: 1) Velocity (Vel.) is the covariate of the analysis of covariance; 2) Location (Loc.) is the treatment variable of the analysis of covariance; 3) Adjusted Location (Adj. Loc.) is the location adjusted for the covariate, velocity; and 4) Date is the treatment variable in the complete randomized block analysis of variance where location was the block variable. Significance levels are shown only when they are < 0.05. Lines underscore the locations which are not significantly different according to Duncan's multiple range test.

Species		Location and Means							F-value Significance			Location and Means							F-value Significance			
		June							Vel.	Loc.	Adj. Loc.	August							Vel.	Loc.	Adj. Loc.	Date
Carp	Loc.	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	$\bar{x}$	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.7	0.0	0.0	0.0	0.0	0.0	0.0		0.02		
Northern squawfish		RVT	RVN	NBF	PCC	PCF	ACS	NBC				RVN	RVT	NBF	NBC	PCF	PCC	ACS				
		27.7	11.0	4.3	3.3	1.7	1.0	0.7	0.04	0.001	0.0004	38.3	33.3	13.0	9.3	5.7	3.0	0.7		0.0001	0.0001	0.001
Peamouth		PCC	ACS	PCF	NBC	NBF	RVN	RVT				PCC	RVT	NBC	ACS	NBF	PCF	RVN				
		1.0	0.3	0.3	0.0	0.0	0.0	0.0				1.0	0.7	0.3	0.0	0.0	0.0	0.0			0.03	
Chiselmouth		RVT	RVN	PCC	PCF	NBC	ACS	NBF				NBF	RVN	RVT	NBC	ACS	PCC	PCF				
		4.7	3.0	1.7	1.0	0.3	0.0	0.0	0.05	0.002	0.001	7.7	5.3	1.0	0.7	0.0	0.0	0.0		0.01	0.03	
Largescale sucker		ACS	NBC	PCC	RVT	RVN	PCF	NBF				PCC	ACS	NBC	RVN	NBF	PCF	RVT				
		10.3	9.7	8.7	7.0	4.3	3.7	2.7	0.05			7.0	6.3	5.7	3.3	2.3	2.3	1.7		0.02	0.02	
Mountain sucker		NBF	NBC	ACS	PCC	PCF	RVN	RVT				NBF	PCF	ACS	NBC	PCC	RVN	RVT				
		3.3	0.3	0.0	0.0	0.0	0.0	0.0		0.04		2.0	0.3	0.0	0.0	0.0	0.0	0.0				
Redside shiner		RVN	RVT	NBC	ACS	NBF	PCC	PCF				RVN	RVT	PCC	NBC	ACS	NBF	PCF				
		1.3	1.3	1.0	0.0	0.0	0.0	0.0				6.7	4.3	1.3	0.5	0.0	0.0	0.0		0.0001	0.0001	0.02
Speckled dace		RVN	NBF	RVT	ACS	NBC	PCC	PCF				RVN	ACS	NBC	NBF	PCC	PCF	RVT				
		2.7	2.0	1.7	0.0	0.0	0.0	0.0		0.004	0.01	1.3	0.0	0.0	0.0	0.0	0.0	0.0		0.02	0.02	0.01
Leopard dace		NBF	ACS	NBC	PCC	PCF	RVN	RVT				NBF	NBC	ACS	PCC	PCF	RVN	RVT				
		23.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0003	0.001	1.7	0.3	0.0	0.0	0.0	0.0	0.0				

Table 5. (Concluded)

Species	Location and Means							F-value Significance			Location and Means							F-value Significance			
	June							Vel.	Loc.	Adj. Loc.	August							Vel.	Loc.	Adj. Loc.	Date
Mountain whitefish	NBF	ACS	NBC	PCC	PCF	RVN	RVT				NBF	PCC	PCF	ACS	NBC	RVN	RVT				
	1.0	0.0	0.0	0.0	0.0	0.0	0.0				2.7	1.3	0.7	0.0	0.0	0.0	0.0				
Chinook salmon	NBC	PCF	RVN	PCC	ACS	NBF	RVT				NBF	ACS	NBC	PCC	PCF	RVN	RVT				
	0.7	0.7	0.7	0.3	0.0	0.0	0.0				0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.02
Rainbow trout	RVN	PCC	ACS	NBC	NBF	PCF	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.7	0.3	0.0	0.0	0.0	0.0	0.0			0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Cutthroat trout	NBF	ACS	NBC	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.7	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
White crappie	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	1.3	0.0	0.0	0.0	0.0	0.0	0.0		0.0001	0.0001	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.03
Smallmouth bass	RVT	ACS	NBC	NBF	PCC	PCF	RVN				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Largemouth bass	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	4.0	0.3	0.0	0.0	0.0	0.0	0.0		0.0001	0.0001	1.7	0.0	0.0	0.0	0.0	0.0	0.0		0.0001	0.0001	0.04
Bluegill	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Channel catfish	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Yellow bullhead	RVN	ACS	NBC	NBF	PCC	PCF	RVT				RVN	ACS	NBC	NBF	PCC	PCF	RVT				
	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.3	0.0	0.0	0.0	0.0	0.0	0.0				
Prickly sculpin	RVN	RVT	NBF	PCC	ACS	NBC	PCF				RVT	RVN	ACS	NBC	NBF	PCC	PCF				
	7.0	6.0	0.3	0.3	0.0	0.0	0.0		0.0001	0.0001	5.3	2.7	0.0	0.0	0.0	0.0	0.0		0.003	0.004	
Torrent sculpin	NBF	ACS	NBC	PCC	PCF	RVN	RVT				NBF	ACS	NBC	PCC	PCF	RVN	RVT				
	2.7	0.0	0.0	0.0	0.0	0.0	0.0		0.04		0.3	0.0	0.0	0.0	0.0	0.0	0.0				
Reticulate sculpin	RVT	RVN	ACS	NBC	NBF	PCC	PCF				RVT	ACS	NBC	NBF	PCC	PCF	RVN				
	1.3	0.7	0.0	0.0	0.0	0.0	0.0				0.7	0.0	0.0	0.0	0.0	0.0	0.0		0.02	0.02	
TOTALS (all species pooled)	RVT	NBF	RVN	ACS	PCC	NBC	PCF				RVN	RVT	NBF	NBC	PCC	ACS	PCF				
	50.0	40.0	32.0	18.0	15.7	13.0	7.3		0.001	0.001	58.0	47.0	30.0	16.7	13.7	9.3	9.0		0.0001	0.0001	

Table 6. Species average catch per 48 hours (two 24-hour sets) and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for hoopnet catches at seven locations of the Willamette River in June and August, 1982. For an explanation of location codes, F-value significance, and underlined groups see Table 5.

Species	Location and Means: June							F-value Significance: Vel.	Loc.	Adj. Loc.	Location and Means: August							F-value Significance: Vel.	Loc.	Adj. Loc.	Date
Carp Loc.	NBC	ACS	NBF	PCC	PCF	RVN	RVT				NBC	ACS	NBF	PCC	PCF	RVN	RVT				
x	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.1	0.0	0.0	0.0	0.0	0.0	0.0				
Northern	NBC	PCF	RVN	RVT	ACS	NBF	PCC				NBC	RVN	RVT	PCC	ACS	NBF	PCF				
squawfish	1.0	0.6	0.5	0.3	0.0	0.0	0.0		0.04		1.3	1.0	0.8	0.5	0.1	0.1	0.1				
Chiselmouth	NBC	RVN	PCF	ACS	NBF	PCC	RVT				RVT	NBC	RVN	NBF	ACS	PCC	PCF				
	0.3	0.3	0.1	0.0	0.0	0.0	0.0				1.3	1.1	0.4	0.3	0.0	0.0	0.0		0.04	0.04	0.03
Largescale	NBC	PCF	RVN	NBF	PCC	ACS	RVT				RVN	ACS	NBC	NBF	RVT	PCC	PCF				
sucker	1.4	1.0	0.6	0.1	0.1	0.0	0.0		0.01		0.6	0.5	0.5	0.3	0.3	0.1	0.0				
Black crappie	ACS	PCF	NBC	NBF	PCC	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.04			0.3	0.1	0.0	0.0	0.0	0.0	0.0				
White crappie	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.5	0.0	0.0	0.0	0.0	0.0	0.0				0.9	0.0	0.0	0.0	0.0	0.0	0.0		0.01		
Bluegill	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	RVN	NBC	NBF	PCC	PCF	RVT				
	0.6	0.3	0.3	0.1	0.0	0.0	0.0		0.04		1.6	0.1	0.0	0.0	0.0	0.0	0.0		0.01		
Pumpkinseed	NBF	ACS	NBC	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.1	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Warmouth	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	0.6	0.0	0.0	0.0	0.0	0.0	0.0				0.1	0.0	0.0	0.0	0.0	0.0	0.0				
Yellow	PCC	ACS	NBC	NBF	PCF	RVN	RVT				RVN	NBC	PCC	ACS	NBF	PCF	RVT				
bullhead	0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.6	0.1	0.1	0.0	0.0	0.0	0.0		0.005	0.005	

Table 7. Average total weight of fish captured, by species, per transect and the results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for the Willamette River electroshocking catches at seven locations during two sampling periods. For an explanation of location codes, F-value significance, and underlined groups see Table 5.

Species		Location and Means							F-value Significance			Location and Means							F-value Significance			
		June							Vel.	Loc.	Adj. Loc.	August							Vel.	Loc.	Adj. Loc.	Date
Carp	Loc.	ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
	$\bar{X}$	553.3	0.0	0.0	0.0	0.0	0.0	0.0				1186.7	0.0	0.0	0.0	0.0	0.0	0.0				
Northern		RVT	RVN	PCC	PCF	NBF	NBC	ACS				NBC	RVN	PCC	PCF	RVT	NBF	ACS				
squawfish		2815.7	1450.3	854.0	417.3	241.0	161.3	9.7	0.04	0.0002	0.0001	1806.0	1639.6	1116.0	1087.3	511.6	161.7	65.7				
Peamouth		PCC	PCF	ACS	NBC	NBF	RVN	RVT				PCC	NBC	RVT	ACS	NBF	PCF	RVN				
		239.3	103.3	2.3	0.0	0.0	0.0	0.0				109.0	101.0	32.3	0.0	0.0	0.0	0.0				
Chiselmouth		RVT	RVN	PCC	PCF	NBC	ACS	NBF				RVN	RVT	NBC	NBF	ACS	PCC	PCF				
		633.0	289.3	232.7	90.3	38.3	0.0	0.0		0.03	0.02	475.0	245.0	110.0	105.3	0.0	0.0	0.0				
Largescale		ACS	NBC	PCC	PCF	RVT	RVN	NBF				PCC	NBC	ACS	PCF	RVN	RVT	NBF				
sucker		6228.0	5238.7	5158.7	2388.3	2198.0	1880.0	995.7				4489.7	4230.0	3141.7	1666.7	1569.3	1433.3	906.3				
Mountain		NBC	NBF	PCC	PCF	RVN	RVT	ACS				PCF	NBF	ACS	NBC	PCC	RVN	RVT				
sucker		52.3	31.3	0.0	0.0	0.0	0.0	0.0				45.0	42.3	0.0	0.0	0.0	0.0	0.0				
Redside		RVT	RVN	NBC	NBF	PCC	PCF	ACS				RVN	RVT	NBC	PCC	ACS	NBF	PCF				
shiner		49.7	30.0	20.3	0.0	0.0	0.0	0.0				120.3	37.0	16.3	13.7	0.0	0.0	0.0		0.0001	0.0001	
Speckled dace		NBF	RVN	RVT	NBC	PCC	PCF	ACS				RVN	ACS	NBC	NBF	PCC	PCF	RVT				
		5.0	4.7	3.3	0.0	0.0	0.0	0.0				3.7	0.0	0.0	0.0	0.0	0.0	0.0		0.04	0.05	0.05
Leopard dace		NBF	ACS	NBC	PCF	PCC	RVN	RVT				NBF	NBC	ACS	PCC	PCF	RVN	RVT				
		23.0	0.0	0.0	0.0	0.0	0.0	0.0				5.3	1.3	0.0	0.0	0.0	0.0	0.0				
Mountain whitefish		NBF	ACS	NBC	PCF	PCC	RVN	RVT				NBF	PCC	PCF	ACS	NBC	RVN	RVT				
		1.3	0.0	0.0	0.0	0.0	0.0	0.0				29.3	19.7	10.0	0.0	0.0	0.0	0.0				0.03
Chinook salmon		PCF	RVN	PCC	NBC	ACS	RVT	NBF				RVT	RVN	PCC	PCF	NBC	NBF	ACS				
		18.0	8.0	5.0	3.3	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Rainbow trout		RVN	RVT	ACS	PCC	PCF	NBC	NBF				RVT	RVN	NBC	NBF	PCC	PCF	ACS				
		65.0	0.0	0.0	0.0	0.0	0.0	0.0		0.02	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0				

Table 7. Concluded.

Species	Location and Means: August							F-value Significance: Vel.	Loc.	Adj. Loc.	Date	Location and Means: June							F-value Significance: Vel.	Loc.	Adj. Loc.
Cutthroat trout	RVT 0.0	RVN 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	ACS 0.0					NBF 48.0	NBC 0.0	PCF 0.0	PCC 0.0	RVN 0.0	RVT 0.0	ACS 0.0			
Black crappie	RVT 0.0	RVN 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	ACS 0.0					ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVT 0.0	RVN 0.0			
White crappie	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0					ACS 228.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.004	
Smallmouth bass	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0					RVT 1.7	RVN 0.0	PCC 0.0	PCF 0.0	NBC 0.0	NBF 0.0	ACS 0.0			
Largemouth bass	ACS 440.7	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0					ACS 1077.7	NBC 76.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0			
Bluegill	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0					ACS 8.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0			
Channel catfish	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0					ACS 1733.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0			
Yellow bullhead	RVN 106.7	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVT 0.0					RVN 58.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0			
Prickly sculpin	RVT 74.7	RVN 68.0	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0					RVN 120.3	RVT 83.0	PCC 1.7	NBF 1.3	PCF 0.0	NBC 0.0	ACS 0.0		0.01	0.01
Torrent sculpin	NBF 7.3	NBC 0.0	PCF 0.0	PCC 0.0	RVN 0.0	RVT 0.0	ACS 0.0					NBF 20.3	NBC 0.0	PCF 0.0	PCC 0.0	RVN 0.0	RVT 0.0	ACS 0.0			
Reticulate sculpin	RVT 3.7	RVN 0.0	PCC 0.0	PCF 0.0	NBC 0.0	NBF 0.0	ACS 0.0		0.04	0.05		RVT 6.3	RVN 1.7	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0			
TOTALS (all species pooled)	NBC 6264.7	PCC 5748.0	ACS 4834.7	RVN 3982.7	PCF 2809.0	RVT 2337.7	NBF 1257.7					ACS 9841.0	PCC 7791.3	NBC 6723.0	RVT 5790.7	RVN 3908.3	PCF 3017.3	NBF 1367.0			

Table 8. Average total weight of fish captured, by species, per 48 hours (two 24-hour sets) and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for hoopnet catches at seven locations of the Willamette River in June and August, 1982. For an explanation of location codes, F-value significance and underlined groups see Table 5.

		Location and Means							F-value Significance			Location and Means							F-value Significance			
Species		June							Vel.	Loc.	Adj. Loc.	August							Vel.	Loc.	Adj. Loc.	Date
Northern squawfish	Loc.	NBC	PCF	RVN	RVT	ACS	NBF	PCC				NBC	RVN	RVT	PCC	PCF	ACS	NBF				
	$\bar{x}$	473.3	467.1	213.4	153.8	0.0	0.0	0.0				688.8	384.6	290.0	221.9	25.0	19.4	15.6		0.04	0.03	
Chiselmouth		RVN	NBC	PCF	ACS	NBF	PCC	RVT				RVT	NBC	RVN	NBF	ACS	PCC	PCF				
		43.5	38.8	33.1	0.0	0.0	0.0	0.0				216.7	190.0	75.9	40.0	0.0	0.0	0.0				
Largescale sucker		NBC	PCF	RVN	PCC	NBF	ACS	RVT				RVN	NBC	ACS	RVT	NBF	PCC	PCF				
		577.9	573.8	153.5	115.0	16.9	0.0	0.0				263.8	229.4	195.0	96.9	61.9	56.3	0.0				
Black crappie		PCF	ACS	NBC	NBF	PCC	RVN	RVT				NBC	ACS	NBF	PCC	PCF	RVN	RVT				
		20.6	10.6	0.0	0.0	0.0	0.0	0.0	0.01			27.5	18.5	0.0	0.0	0.0	0.0	0.0				
White crappie		ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
		59.5	0.0	0.0	0.0	0.0	0.0	0.0				95.3	0.0	0.0	0.0	0.0	0.0	0.0				
Bluegill		ACS	NBF	NBC	PCC	PCF	RVN	RVT				ACS	RVN	NBC	NBF	PCC	PCF	RVT				
		121.5	28.1	23.8	11.8	0.0	0.0	0.0				107.3	11.3	0.0	0.0	0.0	0.0	0.0		0.01		
Pumpkinseed		NBF	ACS	NBC	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
		4.6	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Warmouth		ACS	NBC	NBF	PCC	PCF	RVN	RVT				ACS	NBC	NBF	PCC	PCF	RVN	RVT				
		67.5	0.0	0.0	0.0	0.0	0.0	0.0				4.9	0.0	0.0	0.0	0.0	0.0	0.0				
Yellow bullhead		PCC	ACS	NBC	NBF	PCF	RVN	RVT				RVN	NBC	PCC	ACS	NBF	PCF	RVT				
		39.4	0.0	0.0	0.0	0.0	0.0	0.0				161.3	30.0	21.9	0.0	0.0	0.0	0.0		0.01	0.01	

Table 9. Shannon's diversity index for catches of fish by electroshocking seven Willamette River locations in June and August, 1982.

Location	June 9-11		August 23-25	
	Value	Rank	Value	Rank
Stoutenberg Revetment	0.62	3	0.44	5
Weston Revetment	0.80	1	0.51	3
Five Island Natural Bank	0.66	2	0.69	1
Candiani Natural Bank	0.44	7	0.46	4
Five Island Secondary Channel	0.58	4	0.42	6
Candiani Secondary Channel	0.57	6	0.57	2
Lambert Slough Abandoned Channel	0.57	5	0.41	7

Table 10. Jaccard's similarity index for electroshocker and hoopnet catches of fish from seven Willamette River locations in June and August, 1982.

	June						
	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
Locations	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Stoutenberg Revetment		0.54	0.25	0.31	0.25	0.29	0.12
Weston Bend Revetment			0.22	0.29	0.31	0.54	0.11
Five Island Bar Natural Bank				0.27	0.13	0.25	0.17
Candiani Bar Natural Bank					0.40	0.42	0.29
Five Island Bar Secondary Channel						0.50	0.33
Candiani Bar Secondary Channel							0.27
Average	0.29	0.33	0.22	0.33	0.32	0.38	0.21
	August						
Stoutenberg Revetment		0.50	0.25	0.46	0.22	0.44	0.15
Weston Bend Revetment			0.23	0.42	0.20	0.40	0.23
Five Island Bar Natural Bank				0.31	0.50	0.27	0.14
Candiani Bar Natural Bank					0.18	0.50	0.31
Five Island Secondary Channel						0.43	0.20
Candiani Bar Secondary Channel							0.17
Average	0.34	0.33	0.28	0.36	0.29	0.37	0.20

31. The results of the total weights for each species were slightly different from the catch data. Significantly higher total weights for the following species were recorded from Stoutenberg than at any other location: northern squawfish and chiselmouth for June, and reticulate sculpin for both sampling periods (Tables 7 and 8).

32. The diversity of fishes at Stoutenberg was intermediate to that of the other locations. The diversity indices ranked third and fifth among locations for June and August with scores of 0.62 and 0.44, respectively (Table 9). The fishes present at Stoutenberg revetment were most similar to the species at Weston revetment and least similar to the species caught in Lambert Slough for both June and August (Table 10).

33. The only species that was unique to this location was a single smallmouth bass captured in June.

34. Weston. Twelve different species were collected with the electroshocker, including 270 individuals weighing a total of 23.7 kg (Figures 8 and 9). The predominant species were northern squawfish (55%), prickly sculpin (11%), chiselmouth (9%), redside shiner (9%), and largescale sucker (8%) (Table 4).

35. Significantly greater catches using the electroshocker were recorded from Weston revetment than the other locations for the following species: rainbow trout and prickly sculpin in June; northern squawfish and redside shiner in August; and speckled dace for both sampling periods (Table 5). Hoopnets captured significantly greater numbers of yellow bullheads at Weston than any other location in August (Table 6).

36. The results of the total weights for each species were slightly different from the catch data. Significantly higher total weights were recorded from Weston than any other location for the following species: rainbow trout and prickly sculpin in June; redside shiner and speckled dace in August for the electroshocker (Table 7); and yellow bullhead in August for the hoopnets (Table 8).

37. The diversity of fishes at Weston revetment was the highest among locations in June and the third highest in August, with H' values of 0.80 and 0.51, respectively (Table 9). The species present at Weston were most similar to the species at Stoutenberg revetment and Candiani secondary channel in June, and those of Stoutenberg revetment in August. They were least similar to the species at Lambert Slough in June and Five Island secondary channel in August (Table 10).

38. Subadult rainbow trout and banded killifish were unique to Weston revetment.

Natural Banks

39. Five Island. The total weight of fishes captured at Five Island natural bank was the lowest of any of the locations. The electroshocker captured 210 fish weighing a total of 7.9 kg (Figure 9). However, more species of fish were captured at Five Island natural bank and Candiani natural bank (13 each) than at any other location (Figure 8). Major species included leopard dace (35%), northern squawfish (25%), chiselmouth (11%), mountain sucker (8%), and largescale sucker (7%) (Table 4).

40. Significantly greater catches using the electroshocker were recorded from Five Island natural bank for the following species: torrent sculpin, mountain sucker, and leopard dace in June; and chiselmouth in August (Table 5). The diversity of fishes at Five Island natural bank was high compared to the other locations (Table 9). The indices (H') ranked second and first among the locations for June and August, respectively. The species assemblage at Five Island natural bank was dissimilar to those of all other locations except Five Island secondary channel in August. The species were least similar to those present at Five Island secondary channel in June and Lambert Slough in August (Table 10).

41. Species that were unique to Five Island natural bank include torrent sculpin, cutthroat trout, and a single pumpkinseed sunfish. Also, all but one of the leopard dace and all but two of the mountain suckers were captured at Five Island natural bank.

42. Candiani. A total of 13 species were captured at this natural bank site (Figure 8). However, only one individual was collected for each of these four species: largemouth bass, mountain sucker, leopard dace, and yellow bullhead. The electroshocker catch included 89 fish weighing a total of 39.0 kg (Figure 9). Largescale suckers and northern squawfish were the most abundant species at this location, comprising 52% and 34% of the catch, respectively. Redside shiners comprised 5% of the catch (Table 4).

43. Significantly higher numbers of northern squawfish and largescale suckers were caught by hoopnets in June at Candiani natural bank than at any other location (Table 6). Additionally, the total weight of northern

squawfish collected by hoopnets was significantly higher at this location than at any other in August (Table 8).

44. The diversity of fishes at Candiani natural bank was comparatively low, with H' values ranking seventh in June and fourth in August among the seven locations (Table 9). The species composition of Candiani natural bank was most similar to that of Candiani secondary channel for both June and August, and least similar to that of Five Island natural bank in June and Five Island secondary channel in August (Table 10).

45. There were no species that were unique to Candiani natural bank in spite of the large number of species collected there.

Secondary Channels

46. Five Island. Among the seven locations, Five Island secondary channel yielded the lowest total catch (65 fish), the second lowest total weight (17.5 kg), and the lowest number of species (8) (Figures 8 and 9). The most common species were northern squawfish and largescale sucker, comprising 45% and 36% of the catch, respectively (Table 4).

47. The species diversity of Five Island secondary channel was low compared to other locations, with H' values ranking fourth in June and sixth in August (Table 9). The species composition was most similar to that of Candiani secondary channel in June and Five Island natural bank in August (Table 10). The lowest similarity coefficients were obtained with Five Island natural bank in June and Candiani natural bank in August.

48. No unique species were collected at Five Island secondary channel.

49. Candiani. A relatively high number of species (12) (Figure 8) were captured at Candiani secondary channel, while the number of individuals caught (99) was the second lowest among locations (Appendix A). The total catch by electroshocker included 88 fish weighing a total of 40.6 kg (Figure 9). The most abundant species at this location were largescale sucker (53%), northern squawfish (22%), peamouth (7%), and chiselmouth (6%) (Table 4).

50. Two species--peamouth and largescale sucker--were caught in significantly higher numbers by electroshocking Candiani secondary channel than for any other location in June and August (Table 5).

51. The species diversity of this location varied relative to the other locations, with H' values ranking second lowest (0.57) in June and second highest (0.57) in August (Table 9). The species composition was most similar to that of Weston revetment in June and Candiani natural bank in August (Table 10). The lowest similarity values for Candiani secondary channel were found for comparisons with Five Island natural bank in June and Lambert Slough in August.

52. The only species that was unique to Candiani secondary channel was a single brown bullhead captured in June in a hoopnet.

Abandoned Channel

53. Ten species were collected at Lambert Slough by the two gear types (Figure 8). Largescale sucker was the most common species (61% of the catch), followed by largemouth bass (21%), squawfish (6%), and white crappie (5%) (Table 4). The highest total weight of fish caught by electroshocking at any location was recorded from Lambert Slough: 44.0 kg for 82 fish (Figure 9).

54. Largemouth bass was collected in significantly greater numbers by electroshocking Lambert Slough than in any other location during both sampling periods. The same was true of white crappie in June and carp in August (Table 5). More bluegill were caught in hoopnets at Lambert Slough than at any other location during August (Table 6).

55. The total weights of fish collected at Lambert Slough were significantly higher for white crappie electroshocked in June (Table 7) and for bluegill taken by hoopnet in August than at any other location (Table 8).

56. The diversity of fishes at Lambert Slough was relatively low, ranking fifth in June and last in August among seven locations (Table 9). The average of the similarity indices for Lambert Slough was lower than that of all locations for both sampling periods (Table 10).

57. Species that were unique to Lambert Slough included warmouth, channel catfish, and white crappie. In addition, most of the largemouth bass, carp, and bluegill were captured at this location.

Velocity and Sampling Period Effects

58. The abundance of four species--largescale sucker, northern squawfish, black crappie, and chiselmouth--was significantly affected by water velocity (Tables 5-8). Largescale sucker, chiselmouth, and northern squawfish were collected from sites with a wide range of water velocities. Black crappie numbers were correlated with water velocity because four of the five black crappie taken were collected from stations that had no water current.

59. The differences in the catches for June and August were significant for nine species according to the results of the analysis of variance (Tables 5-8). Of fish caught by electroshocking, the numbers of northern squawfish and redside shiner increased from June to August while black crappie, largemouth bass, prickly sculpin, chinook salmon, and speckled dace decreased. Also, the number of chiselmouth captured in the hoopnets increased from June to August, as did the combined weight of electroshocked mountain whitefish.

Species Distribution Patterns

60. Native species (Table 11) were the most abundant and widely distributed throughout the study area. Northern squawfish and largescale suckers were present in all locations during both sampling periods. Chiselmouth were present in all locations except Lambert Slough, and peamouth were absent only at Five Island natural bank and Weston revetment. Only three native species (northern squawfish, peamouth, and largescale sucker) were collected in Lambert Slough. Most of the introduced species (centrarchids, catfishes, and carp) were found primarily in Lambert Slough, excepting yellow bullhead and smallmouth bass.

Table 11. List of fishes collected in the Willamette River (river miles 58-66), Oregon in June and August, 1982. Asterisks denote fishes that are not native to Oregon.

Scientific Name	Common Name
Petromyzontidae	Lampreys
Lampetra (Entosphenus) tridentata	Pacific lamprey
Catostomidae	Suckers
Catostomus macrocheilus	Largescale sucker
Catostomus platyrhynchus	Mountain sucker
Cyprinodontidae	Killifishes
Fundulus Diaphanus *	Banded killifish
Cyprinidae	Minnows, Carps, Daces, Chubs
Cyprinus carpio *	Carp
Ptychocheilus oregonesis	Northern squawfish
Mylocheilus caurinus	Peamouth
Acrocheilus alutaceus	Chiselmouth
Richardsonius balteatus	Redside shiner
Rhinichthys osculus	Speckled dace
Rhinichthys falcatus	Leopard dace
Salmonidae	Salmons, Trouts, Whitefishes
Prosopium williamsoni	Mountain whitefish
Oncorhynchus tshawytscha	Chinook salmon
Salmo gairdneri	Rainbow trout
Salmo clarki	Cutthroat trout
Ictaluridae	Catfishes
Ictalurus punctatus *	Channel catfish
Ictalurus natalis *	Yellow bullhead
*Ictalurus nebulosus**	Brown bullhead
Centrarchidae	Sunfishes, Basses
Pomoxis annularis *	White crappie
Pomoxis nigromaculatus *	Black crappie
Lepomis macrochirus *	Bluegill
Lepomis gibbosus *	Pumpkinseed
Lepomis gulosus *	Warmouth
Micropterus dolomieui *	Smallmouth bass
Micropterus salmoides *	Largemouth bass
Cottidae	Sculpins
Cottus asper	Prickly sculpin
Cottus rhotheus	Torrent sculpin
Cottus perplexus	Reticulate sculpin

Benthic Invertebrates

Revetments

61. Stoutenberg. Stoutenberg revetment supported the greatest number of benthic invertebrates when totals for both sampling periods were combined (Figure 10). In June, this location supported the greatest number of taxa (57) (Figure 11). The most common taxa in June were *Anisogammarus* (36%), *Paratanytarsus* (12%), Oligochaeta (10%), and *Manayunkia* (10%) (Table 12). The taxa composition in August reflected a decrease in the proportion of *Anisogammarus* to 19%, concommitant with an increase in the proportion in the other predominant taxa: Oligochaeta (21%), *Manayunkia* (20%), and *Orthocladius-Cricotopus* (13%) (Table 13).

62. Many taxa were found in significantly higher densities at Stoutenberg revetment than at any other location. Those taxa were: *Anisogammarus*, *Pacifastacus*, *Paratanytarsus*, *Orthocladius-Cricotopus*, and *Nanocladius* for both sampling periods; Nematomorpha, *Paraleptophlebia*, *Serratella*, *Tricorythodes*, *Hydropsyche*, *Cheumatopsyche*, *Hydroptila*, *Psychomyia*, *Rheocricotopus*, *Potthastia*, and *Xenochironomus* in June; and Oligochaeta, *Manayunkia*, *Centroptilum*, *Ceraclea*, *Endochironomus*, *Dicrotendipes*, and *Ferrissia* in August (Table 14).

63. The following taxa were widespread (present in at least five other locations) but were least abundant at Stoutenberg: *Fluminicola* during June and Tricoptera pupae, *Procladius*, and *Corbicula* during August (Table 14).

64. The diversity of invertebrates at Stoutenberg revetment was intermediate to that of the other locations, with H' values ranking second (1.04) in June and sixth (1.01) in August (Table 15). The taxa collected at Stoutenberg were most similar to those at Weston revetment and least similar to those at Lambert Slough in both June and August (Table 16).

65. The taxa collected only at Stoutenberg were *Zapada*, *Polycentropus*, *Aturus*, and *Xenochironomus*.

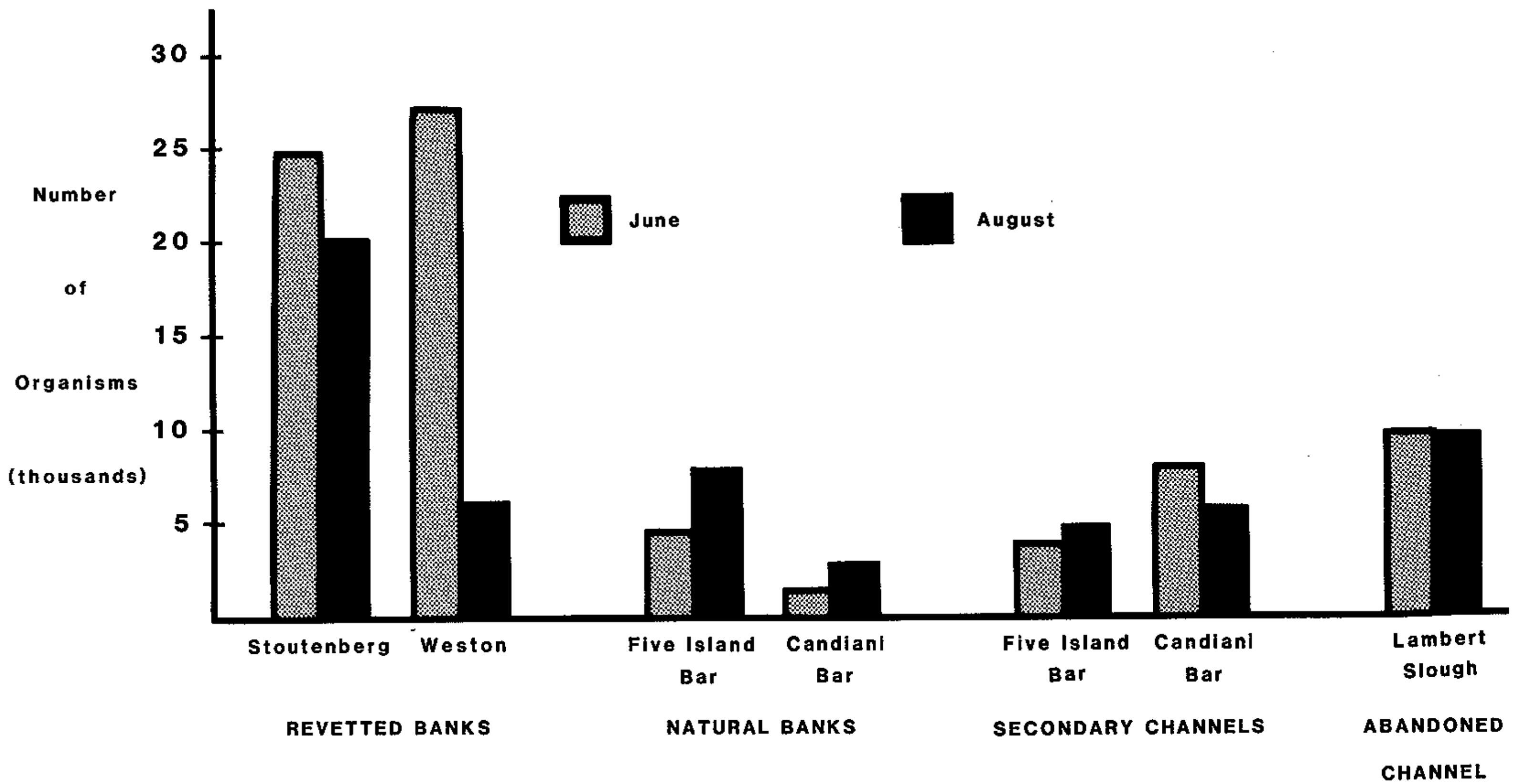

Figure 10. Total number of benthic invertebrates, by sampling period, collected from seven locations within four habitat types of the Willamette River during June and August 1982

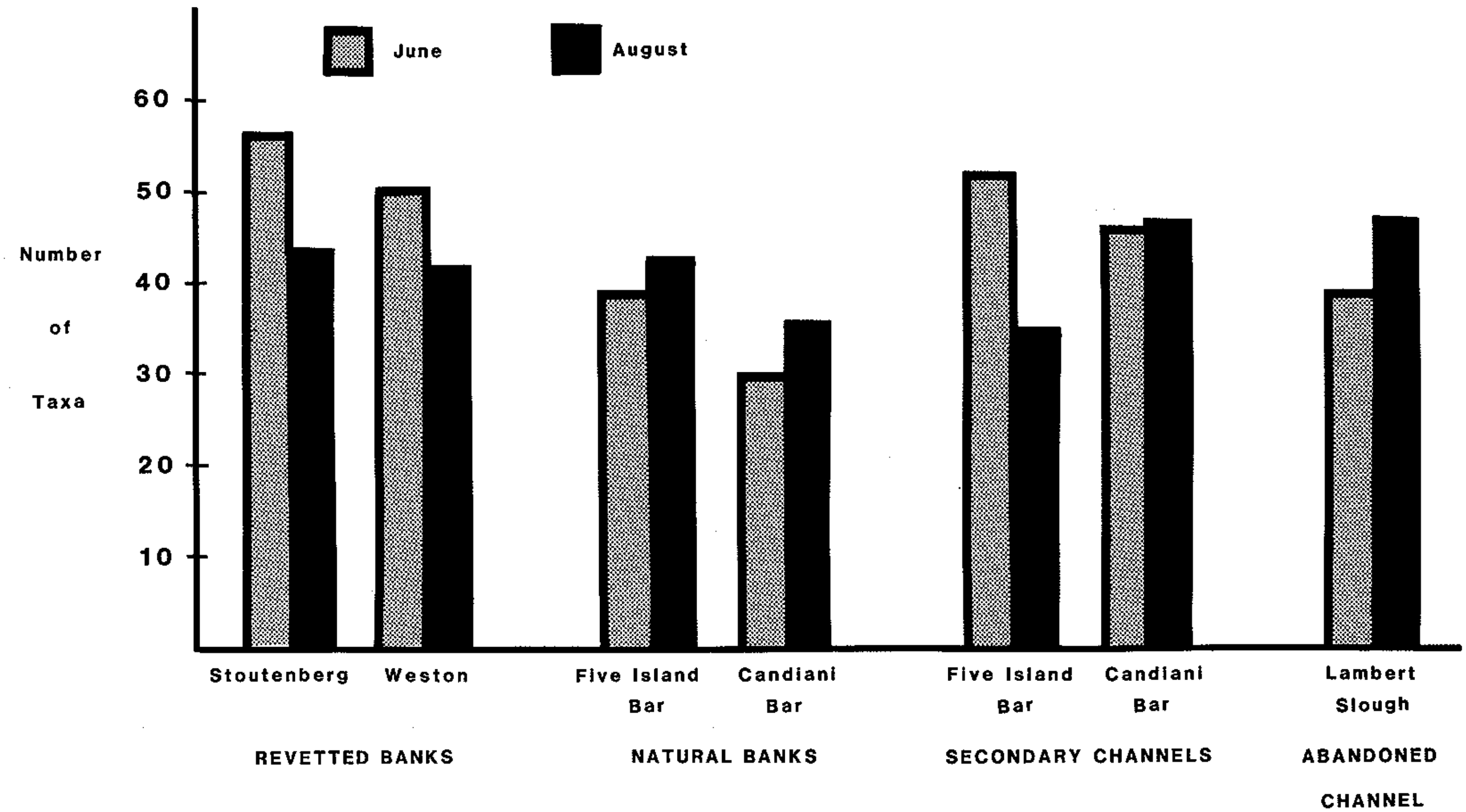

Figure 11. Number of taxa of benthic invertebrates, by sampling period, collected from seven locations within four habitat types of the Willamette River during June and August 1982

Table 12. Percent occurrence by location of the six most abundant taxa of benthic invertebrates collected from river mile 58-66 of the Willamette River, Oregon, in June, 1982.

Revetted Banks				Natural Banks				Secondary Channels				Abandoned Channel	
Stoutenberg		Weston Bend		Five Island Bar		Candiani Bar		Five Island Bar		Candiani Bar		Lambert Slough	
Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%
Anisogammarus	36	*Anisogammarus*	31	*Orthocladius-Cricotopus*	36	Oligochaeta	22	Oligochaeta	33	*Endochironomus*	30	Oligochaeta	60
Paratanytarsus	12	*Manayunkia*	20	*Paratanytarsus*	11	*Orthocladius-Cricotopus*	20	*Chironomus*	15	Oligochaeta	21	*Procladius*	12
Oligochaeta	10	Oligochaeta	18	*Rheotanytarsus*	9	*Paratanytarsus*	19	*Endochironomus*	10	*Chironomus*	9	*Dubiraphia* larvae	5
Manayunkia	10	*Orthocladius-Cricotopus*	5	Oligochaeta	9	*Rheotanytarsus*	13	*Juga*	8	*Juga*	9	*Helobdella*	5
Orthocladius-Cricotopus	9	*Paratanytarsus*	5	Chironomidae pupae	8	Chironomidae pupae	5	*Fluminicola*	6	*Fluminicola*	7	*Asellus*	3
Rheotanytarsus	4	*Dicrotendipes*	4	*Polypedilum*	6	Nematomorpha	4	*Corbicula*	3	*Orthocladius-Cricotopus*	3	*Tanytarsus*	3
Total	81	Total	83	Total	79	Total	83	Total	74	Total	79	Total	88

Table 13. Percent occurrence by location of the six most abundant taxa of benthic invertebrates collected from river miles 58-66 of the Willamette River, Oregon, in August, 1982.

Revetted Banks				Natural Banks				Secondary Channels				Abandoned Channel	
Stoutenberg		Weston Bend		Five Island Bar		Candiani Bar		Five Island Bar		Candiani Bar		Lambert Slough	
Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%
Oligochaeta	21	*Manayunkia*	29	*Fluminicola*	20	Nematomorpha	21	*Fluminicola*	42	*Fluminicola*	33	*Procladius*	26
Manayunkia	20	*Anisogammarus*	15	*Orthocladius-Cricotopus*	17	*Orthocladius-Cricotopus*	20	Sphaeriidae	18	*Juga*	25	Oligochaeta	22
Anisogammarus	19	*Ceraclea*	13	*Rheotanytarsus*	11	*Polypedilum*	15	*Juga*	17	Sphaeriidae	23	Cladopelma	9
Orthocladius-Cricotopus	13	*Orthocladius-Cricotopus*	10	*Eukiefferiella*	11	*Anisogammarus*	9	Oligochaeta	9	Oligochaeta	5	*Asellus*	8
Ceraclea	7	Oligochaeta	10	*Polypedilum*	8	*Stenonema*	9	Nematomorpha	2	*Tricorythodes*	4	*Dubiraphia* larvae	8
Polypedilum	3	*Polypedilum*	3	*Synorthocladius*	4	Sphaeriidae	4	*Paracladopelma*	2	Nematomorpha	4	*Chironomus*	3
Total	84	Total	80	Total	71	Total	78	Total	90	Total	94	Total	76

Table 14. Average invertebrate abundance by taxa and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for invertebrate samples collected at seven locations of the Willamette River in June and August, 1982. For an explanation of location codes, F-value significance, and underlined groups see Table 5.

PHYLUM CLASS ORDER Family Genus, Species		Locations and Means – June							F-value Significance: Vel.	Adj. Loc.	Loc.
NEMATODA	Loc. X̄	ACS 12.0	RVN 8.8	RVT 0.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0			
NEMATOMORPHA		RVT 63.3	RVN 40.3	PCC 37.3	NBF 21.5	NBC 15.8	PCF 14.3	ACS 9.5	0.02	0.03	0.01
ANNELIDA											
OLIGOCHAETA		ACS 1485.0	RVN 1193.3	RVT 620.3	PCC 430.8	PCF 330.5	NBF 103.3	NBC 86.3			
BRANCHIOBDELLIDA		RVN 53.8	RVT 25.5	PCF 1.0	PCC 0.5	NBF 0.3	ACS 0.0	NBC 0.0			
POLYCHAETA Sabellidae Manayunkia speciosa		RVN 1321.8	RVT 601.5	PCC 18.0	PCF 11.3	NBC 0.8	ACS 0.0	NBF 0.0		0.03	0.04
HIRUDINEA Erpobdellidae Dina		PCF 1.0	ACS 0.0	NBF 0.0	NBC 0.0	PCC 0.0	RVN 0.0	RVT 0.0			
Glossiphonidae Helobdella		ACS 114.8	PCF 1.0	NBF 0.5	NBC 0.0	PCC 0.0	RVN 0.0	RVT 0.0			
ARTHROPODA CRUSTACEA OSTRACODA		RVT 0.3	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0			
ISOPODA Asellidae Asellus		ACS 69.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0			
AMPHIPODA Gammaridae Anisogammarus		RVT 2224.5	RVN 2072.3	PCC 27.0	PCF 14.0	NBC 6.5	NBF 2.8	ACS 0.0		0.001	0.001
Talitridae Hyalella azteca		RVN 12.5	RVT 11.3	ACS 4.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0			
DECAPODA Astacidae Pacifastacus leniusculus		RVT 21.0	RVN 13.5	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0		0.0001	0.0001

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means – August							F-value Significance: Vel.	Loc.	Adj. Loc.	Date
NEMATODA	ACS 9.0	PCC 1.0	NBF 0.5	NBC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.0002	0.001	
NEMATOMORPHA	NBC 130.0	NBF 77.8	PCC 57.3	RVN 39.5	RVT 28.0	PCF 26.3	ACS 4.5				
ANNELIDA											
OLIGOCHAETA	RVT 1077.8	ACS 513.8	RVN 150.0	PCF 107.3	PCC 74.3	NBF 47.5	NBC 12.5		0.0001	0.0001	0.04
BRANCHIOBDELLIDA	PCC 32.3	RVT 28.0	RVN 4.3	ACS 0.0	NBC 0.0	NBF 0.0	PCF 0.0				
POLYCHAETA Sabellidae Manayunkia speciosa	RVT 1023.5	RVN 447.5	NBC 6.0	PCF 1.0	PCC 0.5	ACS 0.0	NBF 0.0		0.01	0.01	
HIRUDINEA Erpobdellidae Dina	PCC 3.0	ACS 0.0	NBF 0.0	NBC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.02	0.01	
Glossiphonidae Helobdella	ACS 77.8	NBF 12.5	PCC 4.8	RVN 1.5	NBC 0.0	PCF 0.0	RVT 0.0				
ARTHROPODA CRUSTACEA OSTRACODA	ACS 3.8	PCC 0.3	NBC 0.0	NBF 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
ISOPODA Asellidae Asellus	ACS 195.5	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
AMPHIPODA Gammaridae Anisogammarus	RVT 978.8	RVN 226.5	NBC 55.3	PCC 35.8	ACS 0.5	NBF 0.3	PCF 0.0		0.0001	0.0001	0.02
Talitridae Hyalella azteca	ACS 34.8	RVT 15.5	PCC 0.5	NBC 0.0	NBF 0.0	PCF 0.0	RVN 0.0				
DECAPODA Astacidae Pacifastacus leniusculus	RVT 6.5	RVN 2.0	NBC 0.3	PCC 0.3	NBF 0.0	PCF 0.0	ACS 0.0		0.0001	0.0001	0.01

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Table 14. Continued

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means							F-value Significance			Locations and Means							F-value Significance			
	June							Vel.	Adj. Loc.	Loc.	August							Vel.	Loc.	Adj. Loc.	Date
ARACHNOIDEA																					
HYDRACARINA																					
Lebertiidae																					
Lebertia	RVN 19.3	RVT 10.0	PCC 8.3	NBC 1.0	NBF 0.8	ACS 0.0	PCF 0.0				PCC 24.3	NBF 20.8	RVN 7.5	NBC 7.3	PCF 4.0	RVT 3.0	ACS 0.0				
Arrenuridae																					
Arrenurus	ACS 3.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 20.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Mideopsidae																					
Mideopsis	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 5.5	PCF 2.3	PCC 0.5	NBC 0.0	NBF 0.0	RVN 0.0	RVT 0.0				
Unionicolidae																					
Unionicola	ACS 12.0	RVT 3.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				ACS 61.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.0001	0.0001	
Pionidae																					
Forelia	ACS 23.5	PCF 7.8	PCC 7.0	NBC 0.0	NBF 0.0	RVN 0.0	RVT 0.0				ACS 5.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Piona	ACS 18.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 15.8	NBC 0.0	NBF 0.0	PCC 0.0	P F 0.0	RVN 0.0	RVT 0.0				
Sperchonidae																					
Sperchon	RVT 3.3	PCF 1.3	NBF 0.5	PCC 0.5	ACS 0.0	NBC 0.0	RVN 0.0				NBF 2.5	NBC 1.0	RVT 0.5	ACS 0.0	PCC 0.0	PCF 0.0	RVN 0.0				
Aturidae	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				RVT 3.0	RVN 2.0	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0				
Aturus	RVT 7.3	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Hygrobatidae																					
Atractides	PCC 7.5	RVN 2.5	NBF 0.5	PCF 0.3	ACS 0.0	NBC 0.0	RVT 0.0	0.03			PCC 1.8	ACS 0.0	NBC 0.0	NBF 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
INSECTA																					
EPHEMEROPTERA																					
Leptophlebiidae																					
Paraleptophlebia	RVT 20.3	RVN 6.5	NBC 0.5	ACS 0.0	NBF 0.0	PCC 0.0	PCF 0.0		0.03	0.03	RVT 2.0	RVN 1.5	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0				
Ephemeridae																					
Serratella	RVT 47.0	RVN 22.0	NBF 1.8	PCC 1.8	PCF 1.0	NBC 0.8	ACS 0.0		0.001	0.001	NBF 5.0	ACS 0.0	NBC 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				0.01

(Continued)

Table 14. Continued

PHYLUM / CLASS / ORDER / Family / Genus, Species	June Locations and Means							June F-value Significance Vel.	June Adj. Loc.	June Loc.	August Locations and Means							August F-value Significance Vel.	August Loc.	August Adj. Loc.	August Date
Tricorychidae *Tricorythodes*	RVT 21.0	RVN 11.3	PCC 7.0	NBF 3.5	PCF 3.3	NBC 3.0	ACS 0.0			0.03	NBF 53.5	PCC 52.3	NBC 14.5	RVN 7.3	RVT 5.0	PCF 1.0	ACS 0.0				
Caenidae *Caenis*	ACS 7.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 15.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.05		
Ephemerellidae *Ephemerella*	RVT 17.0	RVN 9.3	PCF 3.5	PCC 1.3	NBF 1.0	NBC 0.5	ACS 0.0				PCC 0.3	ACS 0.0	NBF 0.0	NBC 0.0	PCF 0.0	RVN 0.0	RVT 0.0	0.0001		0.004	0.03
Heptageniidae *Rhithrogena*	NBF 4.3	ACS 0.0	NBC 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0	0.02			PCC 4.3	NBF 2.5	ACS 0.0	NBC 0.0	PCF 0.0	RVN 0.0	RVT 0.0	0.001			
Stenonema	RVN 21.0	RVT 16.3	PCF 5.0	NBF 1.8	NBC 0.5	ACS 0.0	PCC 0.0		0.002	0.002	NBC 55.5	RVN 14.0	NBF 11.5	RVT 11.3	PCC 11.0	PCF 3.8	ACS 0.0				
Heptagenia	RVN 9.0	PCC 5.8	PCF 3.5	NBF 2.8	RVT 0.5	ACS 0.0	NBC 0.0				RVT 3.0	NBF 1.5	PCC 0.5	ACS 0.0	NBC 0.0	PCF 0.0	RVN 0.0				
Baetidae *Centroptilum*	RVN 27.0	RVT 15.8	PCF 3.0	NBC 0.8	ACS 0.0	NBF 0.0	PCC 0.0				RVT 24.8	RVN 2.0	NBF 1.3	ACS 0.0	NBC 0.0	PCC 0.0	PCF 0.0		0.01	0.01	
Baetis	RVT 3.5	NBC 1.0	ACS 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Pseudocloeon	RVT 12.0	NBF 10.8	PCF 5.0	PCC 4.0	RVN 3.5	NVC 1.0	ACS 0.0				NBF 35.8	PCC 4.3	NBC 0.5	PCF 0.5	ACS 0.0	RVN 0.0	RVT 0.0				
ODONATA Coenagriidae	ASC 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 12.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
MEGALOPTERA Sialidae *Sialis*	ACS 16.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ASC 3.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.0001	0.0001	
NEUROPTERA Sisyridae *Climacia*	ACS 6.0	RVN 2.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVT 0.0				NBC 0.3	ACS 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
TRICOPTERA (pupae)	RVT 34.8	RVN 29.3	PCC 3.8	PCF 2.8	NBF 2.3	NBC 0.8	ACS 0.0		0.01	0.01	PCF 2.5	NBF 0.0	PCC 0.0	ACS 0.0	RVN 0.0	RVT 0.0	NBC 0.0				
Hydropsychidae *Hydropsyche*	RVT 34.0	RVN 20.0	PCC 2.3	NBF 0.8	PCF 0.3	NBC 0.0	ACS 0.0		0.003	0.003	PCC 28.5	NBF 8.5	NBC 4.5	PCF 1.3	ACS 0.0	RVN 0.0	RVT 0.0	0.0002		0.05	

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Table 14. Continued

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means: June							F-value Significance: Vel.	Adj. Loc.	Loc.	Locations and Means: August							F-value Significance: Vel.	Loc.	Adj. Loc.	Date
<u>Cheumatopsyche</u>	RVT 93.3	RVN 43.5	PCC 1.8	PCF 1.5	NBF 0.5	ACS 0.0	NBC 0.0		0.0004	0.0004	PCC 20.8	NBF 15.5	NBC 14.3	PCF 6.5	RVN 5.8	RVT 2.0	ACS 0.0				
Hydroptilidae <u>Leucotrichia</u>	RVT 0.3	ACS 0.0	NBC 0.0	NBF 0.0	RVN 0.0	PCF 0.0	PCC 0.0				RVN 2.0	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVT 0.0				
<u>Hydroptila</u>	RVT 16.8	RVN 13.0	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0		0.005	0.005	PCC 10.8	RVT 10.3	RVN 6.0	NBF 0.5	ACS 0.0	NBC 0.0	PCF 0.0				
Leptoceridae <u>Oecetis</u>	ACS 6.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 31.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
<u>Ceraclea</u>	RVN 2.0	RVT 1.5	PCF 0.5	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0				RVT 349.5	RVN 207.0	PCC 14.8	NBC 13.5	PCF 8.0	NBF 3.3	ACS 0.0		0.003	0.004	0.004
Glossosomatidae <u>Glossosoma</u>	PCC 8.8	PCF 5.0	NBF 0.8	ACS 0.0	NBC 0.0	RVN 0.0	RVT 0.0	0.03		0.04	PCC 34.8	NBF 19.0	PCF 15.8	ACS 0.0	NBC 0.0	RVN 0.0	RVT 0.0	0.0001	0.04	0.01	
<u>Protoptila</u>	PCF 6.3	NBF 0.3	ACS 0.0	NBC 0.0	PCC 0.0	RVN 0.0	RVT 0.0		0.03	0.03	PCC 7.8	NBF 2.0	ACS 0.0	NBC 0.0	PCF 0.0	RVN 0.0	RVT 0.0	0.0001		0.01	
Psychomyiidae <u>Psychomyia</u>	RVT 10.8	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				RVN 39.0	RVT 21.5	NBF 5.3	ACS 0.0	NBC 0.0	PCC 0.0	PCF 0.0				
LEPIDOPTERA Pyralidae <u>Parargyractis</u>	RVT 42.8	RVN 9.5	NBF 0.3	ACS 0.0	NBC 0.0	PCC 0.0	PCF 0.0		0.0001	0.0001	RVT 134.0	RVN 47.5	NBF 20.5	ACS 0.0	NBC 0.0	PCC 0.0	PCF 0.0				
COLEOPTERA Elmidae <u>Dubiraphia</u> (larvae)	ACS 116.3	PCC 21.0	RVN 2.3	PCF 1.0	NBC 0.0	NBF 0.0	RVT 0.0		0.0002	0.03	ACS 180.8	PCF 1.3	NBC 0.0	NBF 0.0	PCC 0.0	RVN 0.0	RVT 0.0		0.01		
<u>Dubiraphia</u> (adult)	ACS 6.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 7.5	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
<u>Optioservus</u> (larvae)	NBC 0.5	PCF 0.5	NBF 0.3	ACS 0.0	PCC 0.0	RVN 0.0	RVT 0.0				PCC 3.5	ACS 0.0	NBC 0.0	NBF 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
DIPTERA (pupae) Tipulidae	RVT 2.3	RVN 0.0	PCC 0.0	PCF 0.0	NBF 0.0	NBC 0.0	ACS 0.0				NBF 2.5	NBC 0.0	RVN 0.0	RVT 0.0	PCC 0.0	PCF 0.0	ACS 0.0				
<u>Antocha</u>	RVN 2.0	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVT 0.0				NBF 13.5	RVN 5.8	RVT 3.0	NBC 0.3	ACS 0.0	PCC 0.0	PCF 0.0				0.03
Chaoboridae	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 0.5	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.04		

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Table 14. Continued

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means – June							F-value Significance			Locations and Means – August							F-value Significance			
								Vel.	Adj. Loc.	Loc.								Vel.	Loc.	Adj. Loc.	Date
Simuliidae (pupae)	ACS	NBC	NBF	PCC	PCF	RVN	RVT				PCC	NBC	ACS	NBF	PCF	RVN	RVT				
	0.0	0.0	0.0	0.0	0.0	0.0	0.0				4.8	3.0	0.0	0.0	0.0	0.0	0.0				
Simulium (larvae)	NBF	PCC	ACS	NBC	PCF	RVN	RVT				PCC	NBF	PCF	NBC	ACS	RVN	RVT				
	0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.03			5.5	2.5	0.5	0.3	0.0	0.0	0.0	0.001			
Empididae Hemerodromia (larvae)	RVN	RVT	ACS	NBC	NBF	PCC	PCF				NBF	PCC	NBC	ACS	PCF	RVN	RVT				
	4.8	0.8	0.0	0.0	0.0	0.0	0.0		0.04	0.03	24.3	1.8	0.3	0.0	0.0	0.0	0.0				
Hemerodromia (pupae)	RVN	RVT	ACS	NBC	NBF	PCC	PCF				NBF	ACS	NBC	PCC	PCF	RVN	RVT				
	4.3	3.3	0.3	0.0	0.0	0.0	0.0				1.0	0.0	0.0	0.0	0.0	0.0	0.0				
Ephydridae (larvae)	PCC	PCF	ACS	NBC	NBF	RVN	RVT				ACS	PCC	PCF	NBC	NBF	RVN	RVT				
	7.5	0.5	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Ceratopegonidae Bezzia-Probezzia	ACS	PCF	RVT	NBC	NBF	PCC	RVN				ACS	NBF	NBC	PCF	PCC	RVN	RVT				
	26.5	2.0	0.5	0.0	0.0	0.0	0.0		0.001	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.04
Palpomyia	NBF	PCC	NBC	PCF	ACS	RUN	RVT				PCC	NBC	PCF	NBF	RVT	ACS	RVN				
	9.0	8.8	3.8	2.8	0.0	0.0	0.0	0.01	0.001	0.002	16.3	5.0	2.5	2.0	2.0	0.0	0.0				
Chironomidae (pupae)	RVN	RVT	NBF	NBC	PCC	ACS	PCF				NBF	RVT	RVN	ACS	NBC	PCC	PCF				
	245.3	170.8	99.3	21.0	18.3	1.8	0.0		0.0001	0.0001	74.3	56.3	25.5	21.5	12.5	4.5	2.3				0.002
Rheotanytarsus	RVN	RVT	NBF	NBC	PCC	PCF	ACS				NBF	RVT	RVN	NBC	PCC	PCF	ACS				
	263.5	257.3	105.8	51.8	25.3	7.8	0.0		0.03	0.03	224.3	76.8	21.5	9.0	7.8	3.0	0.0				
Cricotopus	RVN	RVT	NBC	PCF	PCC	NBF	ACS				NBF	RVT	NBC	ACS	PCC	PCF	RVN				
	19.5	10.8	9.5	6.3	2.8	0.3	0.0				35.5	34.8	3.0	0.0	0.0	0.0	0.0		0.01	0.01	
Eukiefferiella	NBF	RVT	RVN	PCF	ACS	PCC	NBC				NBF	RVT	RVN	PCF	ACS	NBF	PCC				
	44.5	10.5	9.0	6.8	6.5	3.8	1.8				218.5	40.0	4.8	1.8	0.0	0.0	0.0				
Synorthocladius	PCC	RVT	PCF	ACS	NBC	NBF	RVN				NBF	RVT	PCC	RVN	PCF	ACS	NBC				
	23.8	8.0	5.5	0.0	0.0	0.0	0.0				79.0	16.0	13.0	4.3	3.8	3.0	0.0				
Paratanytarsus	RVT	RVN	NBF	NBC	PCC	PCF	ACS				RVT	RVN	ACS	PCC	NBC	NBF	PCF				
	765.0	365.5	103.8	75.3	16.8	4.5	4.3		0.0001	0.0001	32.3	8.0	3.0	0.3	0.0	0.0	0.0		0.001	0.001	0.0001
Orthocladius-Cricotopus	RVT	NBF	RVN	NBC	PCC	PCF	ACS				RVT	NBF	RVN	NBC	PCC	PCF	ACS				
	538.3	421.5	369.5	75.8	58.5	14.5	0.0		0.002	0.003	641.0	337.3	156.0	124.3	7.0	4.5	3.3		0.01	0.02	
Endochironomus	PCC	PCF	RVN	ACS	RVT	NBF	NBC				RVT	RVN	NBF	ACS	PCC	NBC	PCF				
	616.3	104.5	75.8	27.5	22.0	16.5	2.3	0.01			30.5	16.0	5.8	3.0	1.5	1.3	0.0				
Dicrotendipes	RVN	RVT	NBF	ACS	PCF	PCC	NBC				RVT	ACS	RVN	NBC	NBF	PCC	PCF				
	264.3	165.0	31.3	26.5	11.3	3.3	1.3		0.0001	0.0001	101.8	58.8	27.5	3.0	2.0	2.0	1.3				0.02

(Continued)

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Table 14. Continued

PHYLUM / CLASS / ORDER / Family / Genus, Species	June: Locations and Means							June F-value Significance: Vel.	June F-value Significance: Adj. Loc.	June F-value Significance: Loc.	August: Locations and Means							August F-value Significance: Vel.	August F-value Significance: Loc.	August F-value Significance: Adj. Loc.	August F-value Significance: Date
Rheocricotopus	RVT 24.0	PCC 19.5	RVN 5.3	ACS 0.0	NBC 0.0	NBF 0.0	PCF 0.0				ACS 0.0	RVT 0.0	RVN 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0				
Nanocladius	RVT 57.5	RVN 53.8	PCF 6.3	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0		0.0003	0.0003	RVT 45.5	NBF 0.0	NBC 0.0	RVN 0.0	PCC 0.0	PCF 0.0	ACS 0.0		0.0001	0.0001	0.02
Stenochironomus	RVN 5.5	RVT 0.0	NBF 0.0	NBC 0.0	PCF 0.0	PCC 0.0	ACS 0.0				RVN 1.8	RVT 0.0	NBF 0.0	PCC 0.0	PCF 0.0	ACS 0.0	NBC 0.0				
Tanytarsus	RVT 71.0	ACS 64.0	RVN 43.8	PCC 27.0	PCF 22.5	NBF 16.0	NBC 10.3				ACS 48.8	RVT 20.3	PCF 6.0	RVN 3.8	PCC 2.5	NBF 1.0	NBC 0.0				0.02
Brillia	RVT 14.5	RVN 7.3	PCF 0.8	PCC 0.5	ACS 0.3	NBC 0.0	NBF 0.0				RVT 0.0	RVN 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	ACS 0.0				
Polypedilum	NBF 74.8	PCC 41.0	RVT 24.5	ACS 21.5	PCF 18.0	RVN 13.5	NBC 4.5				NBF 159.3	RVT 141.3	NBC 97.0	RVN 50.0	PCF 20.0	PCC 15.3	ACS 14.5				0.04
Chironomus	PCC 179.8	PCF 148.0	ACS 48.3	RVN 9.3	RVT 0.3	NBC 0.0	NBF 0.0	0.0002			ACS 85.8	PCF 9.5	NBF 8.5	RVN 4.3	RVT 2.0	PCC 1.0	NBC 0.0		0.0001	0.0002	
Thienemanniella	NBF 30.8	NBC 2.8	PCC 1.3	RVT 0.8	PCF 0.5	ACS 0.0	RVN 0.0				ACS 4.8	RVT 4.3	PCC 2.0	NBC 0.0	NBF 0.0	PCF 0.0	RVN 0.0				
Stempellinella	PCC 19.5	PCF 7.3	ACS 0.0	NBC 0.0	NBF 0.0	RVN 0.0	RVT 0.0	0.001			RVN 0.0	RVT 0.0	ACS 0.0	PCC 0.0	PCF 0.0	NBC 0.0	NBF 0.0				
Procladius	ACS 287.5	PCF 19.0	RVN 9.0	RVT 0.3	NBC 0.0	NBF 0.0	PCC 0.0		0.001	0.03	ACS 620.0	PCF 8.5	NBC 3.0	PCC 0.5	RVN 0.5	NBF 0.0	RVT 0.0		0.02		
Micropsectra	RVN 9.3	NBC 3.3	ACS 0.3	NBF 0.0	PCC 0.0	PCF 0.0	RVT 0.0				ACS 3.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Paracladopelma	PCC 19.0	PCF 1.5	NBC 0.5	ACS 0.0	NBF 0.0	RVN 0.0	RVT 0.0				PCF 20.3	NBF 6.0	PCC 5.3	RVN 3.8	ACS 0.0	NBC 0.0	RVT 0.0	0.02			
Cryptochironomus	PCC 19.0	ACS 0.3	NBC 0.0	NBF 0.0	PCF 0.0	RVN 0.0	RVT 0.0				ACS 27.8	NBF 15.8	PCF 12.5	NBC 6.3	PCC 4.3	RVT 4.3	RVN 0.5	.04			
Potthastia	RVT 29.5	NBF 9.5	RVN 6.8	NBC 4.0	ACS 0.0	PCC 0.0	PCF 0.0		0.04	0.04	NBC 6.0	ACS 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				0.03
Cladopelma	ACS 27.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.02		ACS 222.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0		0.03		

(Continued)

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Table 14. Concluded

PHYLUM / CLASS / ORDER / Family / Genus, Species	Locations and Means: June							F-value Significance: Vel.	Adj. Loc.	Loc.	Locations and Means: August							F-value Significance: Vel.	Loc.	Adj. Loc.	Date
Ablabesmyia	RVT 8.0	ACS 4.5	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				ACS 6.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Parachironomus	RVT 10.8	ACS 6.8	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				ACS 19.3	RVT 8.8	RVN 0.5	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0				
Djalmabatista	ACS 4.8	RVT 0.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				ACS 0.3	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0	RVT 0.0				
Xenochironomus	RVT 18.8	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0		0.04	0.04	RVT 18.3	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RVN 0.0				
Paralauterborniella	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	PCF 0.0	RUN 0.0	RVT 0.0				PCF 2.3	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	RVN 0.0	RVT 0.0		0.02	0.01	
MOLLUSCA																					
GASTROPODA																					
Juga	PCC 178.0	PCF 83.3	ACS 0.0	NBC 0.0	NBF 0.0	RVN 0.0	RVT 0.0		0.01	0.02	PCC 361.0	PCF 201.0	NBF 18.8	NBC 17.0	RVN 11.3	RVT 2.0	ACS 0.0				
Hydrobiidae Fluminicola	PCC 153.8	PCF 61.3	NBF 23.8	RVN 0.5	ACS 0.3	NBC 0.0	RVT 0.0		0.001	0.002	PCF 498.0	PCC 480.0	NBF 397.3	ACS 8.0	RVT 4.3	NBC 3.3	RVN 1.8				0.01
Ancylidae Ferrissia	PCF 6.0	RVN 2.0	RVT 2.0	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0		0.03	0.02	RVT 43.5	RVN 5.3	PCC 1.0	ACS 0.0	NBC 0.0	NBF 0.0	PCF 0.0		0.001	0.001	
Planorbidae Vorticifex (Parapholyx)	PCF 0.5	ACS 0.0	NBC 0.0	NBF 0.0	PCC 0.0	RVN 0.0	RVT 0.0				PCF 3.5	PCC 1.8	ACS 0.0	NBC 0.0	NBF 0.0	RVN 0.0	RVT 0.0				
PELECYPODA																					
Margaritiferidae Margaritifera	ACS 0.3	PCF 0.3	NBC 0.0	NBF 0.0	PCC 0.0	RVN 0.0	RVT 0.0				ACS 0.3	PCF 0.3	NBC 0.0	NBF 0.0	PCC 0.0	RVN 0.0	RVT 0.0				
Corbiculidae Corbicula	PCF 31.0	PCC 4.8	RVN 1.8	ACS 0.0	NBC 0.0	NBF 0.0	RVT 0.0	0.01	0.003	0.001	PCF 8.5	PCC 2.3	RVN 1.8	NBC 0.5	ACS 0.3	NBF 0.3	RVT 0.0		0.02	0.01	
Sphaeriidae	PCF 19.5	RVN 15.5	PCC 14.5	RVT 3.3	ACS 0.0	NBC 0.0	NBF 0.0				PCF 220.8	PCC 125.5	ACS 60.8	NBC 22.3	RVT 6.0	RVN 3.0	NBF 1.0	0.01			
TOTALS (all taxa pooled)	RVN 6764.3	RVT 6219.0	ACS 2398.8	PCC 2100.5	NBF 1176.3	PCF 1025.3	NBC 367.5		0.001	0.001	RVT 5052.3	ACS 2355.3	NBF 1949.8	RVN 1561.5	PCC 1470.5	PCF 1196.0	NBC 626.3		0.02	0.03	

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Table 15. Shannon's diversity index for benthic invertebrates collected from seven Willamette River locations in June and August, 1982.

Location	June		August	
	Value	Rank	Value	Rank
Stoutenberg Revetment	1.04	2	1.01	6
Weston Revetment	0.96	6	1.05	4
Five Island Natural Bank	0.97	5	1.15	1
Candiani Natural Bank	0.97	4	1.08	3
Five Island Secondary Channel	1.11	1	0.84	7
Candiani Secondary Channel	1.04	3	1.03	5
Lambert Slough Abandoned Channel	0.73	7	1.11	2

Table 16. Jaccard's similarity index for benthic invertebrates collected from seven Willamette River locations in June and August, 1982.

	June						
	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
Locations	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Stoutenberg Revetment		0.61	0.39	0.42	0.43	0.41	0.25
Weston Bend Revetment			0.46	0.40	0.50	0.48	0.21
Five Island Bar Natural Bank				0.53	0.49	0.57	0.15
Candiani Bar Natural Bank					0.38	0.41	0.17
Five Island Bar Secondary Channel						0.64	0.21
Candiani Bar Secondary Channel							0.19
Average	0.42	0.44	0.43	0.39	0.44	0.45	0.20

	August						
Stoutenberg Revetment		0.65	0.49	0.42	0.38	0.48	0.24
Weston Bend Revetment			0.53	0.44	0.45	0.49	0.27
Five Island Bar Natural Bank				0.47	0.48	0.55	0.22
Candiani Bar Natural Bank					0.43	0.46	0.18
Five Island Secondary Channel						0.51	0.27
Candiani Bar Secondary Channel							0.32
Average	0.43	0.47	0.46	0.40	0.42	0.47	0.25

66. Weston. Weston revetment supported the greatest number of invertebrates for a sampling period, with 27,128 organisms representing 51 taxa collected in June (Figures 10 and 11). In August, however, Weston ranked fourth in number of invertebrates, with 6,288 representing 42 taxa (Figures 10 and 11). The patterns of taxa composition were similar to that of Stoutenberg, with *Anisogammarus* decreasing from 31% of the total in June to 14% in August (Tables 12 and 13). Other abundant taxa were *Manayunkia* (20%) and Oligochaeta (18%) in June (Table 12), and *Manayunkia* (28%), *Ceraclea* (13%), *Orthocladius-Cricotopus* (10%), and Oligochaeta (10%) in August (Table 13).

67. Six taxa were collected in significantly higher densities at Weston than at any other location in June: *Manayunkia*, *Stenonema*, *Hemerodromia*, *Rheotanytarsus*, *Dicrotendipes*, and Chironomidae pupae (Table 14). None, however, was at significantly higher densities at Weston than at the other locations in August.

68. The following taxa were widespread (present in at least five locations) but were least abundant or absent at Weston revetment: *Thienemanniella* during June, and *Palpomyia*, *Cryptochironomus*, and *Fluminicola* during August (Table 14).

69. The diversity of invertebrates at Weston revetment was comparatively low, ranking sixth in June ($H' = 0.96$) and fourth in August ($H' = 1.05$) among the seven locations (Table 15). The invertebrate taxa composition of Weston was most like that of Stoutenberg and least like that of Lambert Slough during both sampling periods (Table 16).

70. The only taxa found exclusively at Weston revetment were three genera of Chironomidae: *Symposiocladius*, *Stictochironomus*, and *Stenochironomus*.

Natural Banks

71. Five Island. The benthic invertebrates at Five Island natural bank were notably less abundant in June than in August. Only 4,712 individuals in 39 taxa were taken in June, while 7,949 in 43 taxa were collected in August (Figures 10 and 11). The most numerous taxa were *Orthocladius-Cricotopus* (17%), *Paratanytarsus* (11%), *Rheotanytarsus* (9%), and Oligochaeta (9%) in June (Table 12), and *Fluminicola* (20%), *Orthocladius-Cricotopus* (17%), *Rheotanytarsus* (11%), and *Eukiefferiella* (11%) in August (Table 13).

72. Palpomyia were significantly more abundant in June at Five Island natural bank than at any other location, as were Cricotopus in August (Table 14).

73. The following taxa were widespread (present in at least five locations) but were absent or least abundant at Five Island natural bank: Manayunkia during both sampling periods, Brillia and Chironomus during June, and Procladius and Sphaeriidae during August (Table 14).

74. The diversity of invertebrates at Five Island natural bank increased from fifth highest ($H' = 0.97$) in June to the highest ($H' = 1.15$) of any location in August (Table 15). The invertebrate taxa composition was most similar to that of Candiani secondary channel and least similar to that of Lambert Slough during both sampling periods (Table 16).

75. Three genera--Anystis, Dicosmoecus, and Placobdella--were found only at Five Island natural bank.

76. Candiani. Candiani natural bank supported the lowest densities of invertebrates (1,547 in June, 2,538 in August) and the fewest taxa (30 in June) of any location (Figures 10 and 11). The most abundant taxa in June were Oligochaeta (22%), Orthocladius-Cricotopus (20%), Paratanytarsus (19%), and Rheotanytarsus (14%) (Table 12), while Nematomorpha (21%), Orthocladius-Cricotopus (20%), Polypedilum (15%), and Stenonema (9%) were most numerous in August (Table 13).

77. Numerous widespread taxa were either absent or least abundant at this location. These were: Oligochaeta, Tanytarsus, and Chironomus during both sampling periods; Branchiobdellida, Heptagenia, Hydropsyche, Cheumatopsyche, Eukiefferiella, Endochironomus, Dicrotendipes, Brillia, Polypedilum, and Fluminicola during June; and Synorthocladius and Tricoptera pupae during August (Table 14).

78. The diversity of invertebrates at Candiani natural bank was intermediate with respect to the other locations, ranking fourth ($H' = 0.97$) in June and third ($H' = 1.08$) in August (Table 15). The taxa collected at Candiani natural bank were most similar to those at Five Island natural bank, and were least similar to those of Lambert Slough in both June and August (Table 16).

79. Taxa that were found only at Candiani natural bank are Claassenia, Brachycentrus, and Pentaneura.

Secondary Channels

80. Five Island. Five Island secondary channel supported the second lowest densities of invertebrates in June (4,075) and in August (4,916), as well as the fewest taxa (35) for August (Figures 10 and 11). The taxa of greatest abundance in June were Oligochaeta (32%), *Chironomus* (15%), *Endochironomus* (10%), *Juga* (8%), and *Fluminicola* (6%) (Table 12). The proportions were very different in August, however, with *Fluminicola* (42%), Sphaeriidae (18%), *Juga* (17%), and Oligochaeta (9%) being the predominant taxa (Table 13).

81. Four taxa were found in significantly higher densities at Five Island secondary channel than at any other location: *Corbicula* during both sampling periods, *Protoptila* and *Ferrissia* in June, and *Paralauterborniella* in August (Table 14).

82. The following widespread (present in at least five locations) taxa were least abundant or absent at Five Island secondary channel: Chironomidae pupae during both sampling periods; *Lebertia*, *Endochironomus*, and *Dicrotendipes* in June; and *Anisogammarus* in August (Table 14).

83. The diversity of invertebrates at this location decreased from the highest ($H' = 1.11$) of any location in June to the lowest ($H' = 0.85$) in August (Table 15). The invertebrate taxa found at Five Island secondary channel were most similar to those at Candiani secondary channel and least similar to those at Lambert Slough during both sampling periods (Table 16).

84. The only taxa found exclusively at Five Island secondary channel were *Paralauterborniella* and *Kiefferulus*.

85. Candiani. The density of benthic invertebrates at Candiani secondary channel was moderately low relative to the other locations, ranking fourth (8,227) in June and fifth (5,971) in August (Figure 11). However, the number of taxa collected ranked high: first (47) for the August sampling period and second (46.5) for the average of the two periods combined. The taxa comprising the majority of the samples in June were *Endochironomus* (30%), Oligochaeta (21%), *Chironomus* (9%), *Juga* (9%), and *Fluminicola* (7%) (Table 12). *Fluminicola* was the most abundant taxa in August (33%), followed by *Juga* (25%), Sphaeriidae (23%), and Oligochaeta (5%) (Table 13).

86. Glossosoma was collected in significantly higher densities at Candiani secondary channel than at any other location during both sampling periods (Table 14). Similarly, Juga and Fluminicola were more numerous during June, and Dina, Ephemerella, and Hydropsyche were more abundant during August at this location than at any other.

87. Stenonema was absent from Candiani secondary channel in June. It was the only widespread (present in at least five locations) taxon present during either sampling period that was least abundant at this location (Table 14).

88. The diversity of invertebrates at Candiani secondary channel was similar in the two sampling periods, with H' values of 1.04 and 1.03, ranking third and fifth in June and August, respectively (Table 15). The invertebrate composition at this location was most like that of Five Island secondary channel in June and Five Island natural bank in August, and least like that of Lambert Slough for both sampling periods (Table 16).

89. Three taxa, Epeorus, Robackia, and Hydrobaenus, were collected only at Candiani secondary channel, and each was found there only during June.

Abandoned Channel

90. Lambert Slough supported the highest densities of invertebrates of all locations except the revetments. In June, 9,959 invertebrates representing 39 taxa were collected; 9,870 individuals representing 47 taxa were collected in August (Figures 10 and 11). Oligochaeta and Procladius were the most abundant taxa at Lambert Slough during both sampling periods (Tables 12 and 13). There was, however, a change in the relative importance of the two as Oligochaeta dropped from 60% of the invertebrates in June to just 22% in August, while Procladius increased from 12% in June to 26% in August.

91. Several taxa were significantly more abundant at Lambert Slough than at any other location, including: Dubiraphia larvae and Cladopelma during both sampling periods; Bezzia-Probezzia and Procladius in June; and Nematoda, Caenis, Sialis, Chironomus, Unionicola, and Chaoboridae in August (Table 14).

92. Many widespread (present in at least five locations) taxa were found to be absent or least abundant at Lambert Slough. These taxa were: Nematomorpha, *Manayunkia*, *Tricorythodes*, *Stenonema*, *Cheumatopsyche*, *Lebertia*, *Rheotanytarsus*, and *Orthocladius-Cricotopus* during both sampling periods; Branchiobdellida, *Anisogammarus*, *Serratella*, *Ephemerella*, *Heptagenia*, *Pseudocloeon*, *Hydropsyche*, Tricoptera pupae, *Cricotopus*, *Paratanytarsus*, and *Thienemanniella* in June; and *Ceraclea*, *Palpomyia*, *Polypedilum*, and *Juga* in August (Table 14).

93. The diversity of invertebrates increased from June to August at Lambert Slough, being the lowest ($H' = 0.72$) of any location in June and the second highest ($H' = 1.09$) in August (Table 15). The taxa from Lambert Slough were the least similar to those from every other location, and scored the lowest average similarity index in both June and August. The locations with taxa most similar to those of Lambert Slough were Stoutenberg revetment in June and Candiani secondary channel in August. The taxa of the two natural bank locations were least similar to those of Lambert Slough during both sampling periods (Table 16).

94. More taxa (20) were found exclusively at Lambert Slough than for any other location. These taxa were: Turbellaria, *Erpobdella*, *Asellus*, *Arrenurus*, *Piona*, Isotomidae, *Hexagenia*, *Caenis*, Coenagriidae, *Ischnura*, Homoptera, *Sialis*, *Sisyra*, *Oecetis*, *Dubiraphia* (adults), *Bezzia-Probezzia*, *Cladopelma*, *Glyptotendipes*, *Psectrotanypus*, and *Gyraulus*.

Velocity and Sampling Period Effects

95. The abundances of 15 taxa of benthic invertebrates were significantly affected by water velocity according to the results of the analysis of covariance (Table 14). The taxa associated with fast water included *Rhithrogena*, *Glossosoma*, and *Simulium* for both sampling periods; *Palpomyia*, *Parargyractis*, and *Corbicula* during June; and *Hydropsyche* during August. The taxa associated with moderate or slow water currents such as the revetments and the pools in the secondary channels include *Atractides*, *Stempellinella*, Nematomorpha, and *Endochironomus* in June and *Paracladopelma*, *Cryptochironomus*, and Sphaeriidae in August. The taxa associated with slow or still water currents such as Lambert Slough or the pools in the secondary channels include *Chironomus* in June and *Ablabesmyia* in August.

96. The abundances of 15 taxa of benthic invertebrates differed significantly between the June and August samples according to the results of the analysis of variance (Table 14). The taxa that increased in abundance included *Ceraclea*, *Antocha*, *Polypedilum*, and *Fluminicola*. The taxa that decreased in abundance were Oligochaeta, *Anisogammarus*, *Pacifastacus*, *Serratella*, *Ephemerella*, *Bezzia-Probezzia*, *Paratanytarsus*, *Dicrotendipes*, *Nanocladius*, *Tanytarsus*, and *Potthastia*.

PART IV: DISCUSSION

Habitat Characteristics

Revetments

97. Revetments resulted in several physical changes in the riverine habitat, particularly in terms of the substrate and water velocity. Revetments were composed of large rocks with numerous interstitial spaces, as compared to gravel or sand and silt constituents at nonrevetted sites. Velocities were moderate (26-72 cm/sec) and fairly uniform throughout each revetted location. Another notable characteristic of the revetments was the uniformly steep shoreline gradient that limited the area of shallow water habitat.

Natural Banks

98. Natural banks were most heterogeneous than the revetments. Bottom types included gravel at Five Island natural bank, and sand and silt at Candiani natural bank. Water velocities were more variable and were faster than at the revetments (46-123 cm/sec). Five Island natural bank had a gentle shoreline gradient which resulted in extensive shallow water habitat. However, the eroding bank at Candiani was irregular, steep, and limited in the amount of shallow water habitat.

Secondary Channels

99. Secondary channels were the most heterogenous in terms of water velocity and substrate. Water velocity ranged greatly from slow pool areas (e.g., 0 cm/sec) to the fast shallow areas (e.g., 123 cm/sec). Bottom types were primarily gravel, except in the pools which contained silt and sand as well. Both secondary channels were narrower than the main river. Other characteristics of the secondary channels that were not found in the habitats of the main river were the thick, overhanging shoreline vegetation and the abundance of woody debris such as submerged logs and fallen trees.

Physical and Water Quality Characteristics

Revetments, Natural Banks, and Secondary Channels

100. Water quality parameters were homogeneous throughout riverine habitats (revetments, natural banks, and secondary channels) examined in this study. The various types of riverine habitat did not differ in measures of water temperature, dissolved oxygen, turbidity, pH, oxidation-reduction potential, or conductivity. This may have been due to relatively high flow rates in the Willamette that did not allow sufficient time for changes to develop over short distances.

Abandoned Channel

101. Lambert Slough had different physical and water quality characteristics as compared to the riverine locations because of a lack of flow through the slough during the time of the study. The main physical differences were a lack of water current and the degree of silt and sand in the substrate (Appendix C). Like the secondary channels, the shoreline of Lambert Slough was lined with overhanging terrestrial vegetation, and submerged logs and snags were scattered throughout. Water temperature in Lambert Slough may be a limiting factor to cool-water fishes since it was 1-2° C higher than the main river in August. Dissolved oxygen was low (<5 ppm) in some sections of the slough, primarily in the deeper areas, as recorded in June, and this may affect the distribution of organisms.

Distributional Patterns of Aquatic Organisms

Revetments

102. Assemblages at the revetments were characterized by high densities of smaller fishes, but species richness and diversity were lower than at the natural banks. Abundance of smaller fishes at the revetments may have been a result of the moderate water current and/or the presence of the interstitial spaces (Hunt 1968; Menzel and Fierstine 1976; Winger et al. 1976). Small fish generally prefer less water current than do larger fish of the same species, and small fish may be more successful at foraging for food and avoiding predation within the interstitial spaces.

103. Most fishes at the revetments, including young northern squawfish, redside shiner, and prickly sculpin, are generally bottom oriented and feed primarily on invertebrates. Largescale sucker and chiselmouth are also bottom oriented but their diet includes algae and diatoms along with invertebrates. The riprap affords substrate for diatom growth. Piscivorous fishes were occasionally found at the revetments, among them yellow bullhead, northern squawfish adults, and smallmouth bass, although each of these species will also utilize invertebrates as part of their diet.

104. The diversity of benthic invertebrates at revetments was comparable to that of nonrevetted locations in spite of greater numbers of benthic invertebrate taxa supported by the revetments. Comparison of the diversity values may be misleading since the values are all close to each other and the values for invertebrates are based on taxa and not species.

105. Several physical factors of revetted banks may contribute to the higher densities of invertebrates. First, large rocks provide a variety of microhabitats for the organisms by creating numerous interstitial spaces and large surface areas. The crayfish, Pacifastacus, and the aquatic caterpillar, Parargyractis, are examples of organisms that benefit from these two characteristics. Another factor benefiting benthic invertebrates is the stability of the revetments (Solomon et al. 1975; Johnson et al. 1974; Menzel and Fierstine 1976). Nonrevetted locations are subject to bank erosion, which could displace organisms or make the microhabitats unsuitable for survival or reproduction. Benthic invertebrates at revetments may also benefit from the moderate water currents and the protection afforded by large rocks and their interstitial spaces. These two characteristics may reduce the susceptibility of the benthic invertebrates to become displaced and drift with the current.

106. The functional groups represented by invertebrate taxa at the revetments included grazers, scrapers, filter feeders, and scavengers. The grazers and scrapers included numerous genera of Ephemeroptera, Tricoptera, and Chironomidae, as well as the lepidopterid Parargyractis. These herbivorous genera probably forage on the large surface areas of the rocks. The filter feeders include Manayunkia, Hydropsyche, and Cheumatopsyche, all of which attach to the substrate and capture food with either tentacles or nets. The scavengers include the crayfish Pacifastacus and the amphipod

Anisogammarus. Both of these genera probably benefit from the interstitial spaces at the revetments, as they prefer to stay hidden during the day. The Branchiobdellida, which are commensal with crayfish, were also more abundant at the revetments than at the other locations.

Natural Banks

107. The heterogeneity of the natural bank habitats promotes greater diversity and species richness of aquatic organisms, but it supports lower densities of organisms than the more homogeneous revetted habitats. The natural bank locations had greater numbers of fish species than did other locations, and the diversity of benthic invertebrates at Five Island natural bank was high in August. The range of water velocities and substrates at the natural banks was greater than at the revetments and may have contributed to the greater number of fish species found there. Water velocities were comparable between the two natural bank locations, but the eroding bank at Candiani may have affected the composition of the fish community by changing the substrate and reducing the shallow water habitat. Candiani natural bank supported fewer, but larger, fish than did Five Island natural bank. Most of the fishes captured at Candiani were largescale suckers and northern squawfish, both large fish common throughout the study area. Other species collected there were either uncommon or represented by single fish, suggesting that Candiani natural bank was not preferred habitat for those species. The smooth sand and silt bottom and the lack of shallow water habitat may not be suitable for juvenile fishes and many smaller lotic fishes that normally seek the slower water velocities along irregular rock bottoms or the shallow margins along shore.

108. The fish community at Five Island natural bank was unusual in two respects. First, the fish were very small, probably because the water was very shallow. Second, several species commonly associated with tributaries of the Willamette were more abundant here than in the other locations. These fish, including torrent sculpin, mountain whitefish, mountain sucker, and cutthroat trout, probably benefit from the swift, shallow water and gravel bottom which resembles that of the tributary streams.

109. The dominant fish at Candiani natural bank were the primarily herbivorous largescale sucker and the omnivorous northern squawfish. Neither relies entirely on benthic invertebrates for its diet, which may account for the high densities of these species at Candiani as well as the low densities of other species. Insects dominate the diets of the two most abundant species at Five Island natural bank--leopard dace and juvenile northern squawfish. The other abundant species at Five Island--chiselmouth, mountain sucker, and largescale sucker--are herbivorous grazers.

110. The community of fish at Five Island natural bank included several unique, predominant species that were rarely found in other sites. Also, the similarity indices for fishes were relatively low, suggesting that the fish assemblage at Five Island natural bank was not similar to the assemblages at the other locations. Only Lambert Slough had a more unique fish assemblage.

111. In contrast, Five Island natural bank supported only two unique taxa of benthic invertebrates and, except for *Eukiefferiella*, the major taxa are common at other locations. Bank erosion causes degradation of habitat, displacement of organisms, and change in sediment type. It is probably responsible for the lower number of taxa and the lower abundance of organisms at Candiani as compared to the Five Island natural bank. Because the substrate is composed of fine silt and sand, the flow of oxygenated water through the substrate is reduced. This affects both the abundance of organisms and the maximum depth in the substrate at which they can occur. Also, organisms have difficulty attaching to the silt and sand substrate in fast water. Organisms that appeared to be adversely affected by erosion include tricopterans, gastropods, and pelecypods.

112. The most abundant taxa at Candiani natural bank were herbivorous chironomids, the particle-feeding oligochaetes, and the parasitic Nematomorpha. The abundant taxa at Five Island natural bank were herbivorous chironomids and particle-feeding oligochaetes. Other herbivores at Five Island included the net-building *Cheumatopsyche*, grazers such as *Fluminicola*, and the scraper *Glossosoma*.

Secondary Channels

113. Fish and invertebrate populations in the secondary channels were surprisingly low in terms of abundance, diversity, and the number of taxa.

Relatively high values for these parameters were expected because of the wide variety of water velocities and substrates found in the secondary channels.

114. Catches of fishes in the secondary channels were low in number of individuals and number of species compared to the other locations. The species compositions were not particularly distinctive, as only one unique species was collected and catches at both locations were dominated by the most common species in the river--northern squawfish and largescale sucker. One factor that may have reduced the catches in the two secondary channels was the inability to maneuver among the partially submerged logs and overhanging shoreline vegetation, which precluded electroshocking in the slower, shallower water close to shore where smaller fish are generally more abundant. Several small species were more abundant in catches from the revetted and natural bank habitats than from the secondary channels. These include redside shiner, mountain sucker, speckled dace, leopard dace, prickly sculpin, and torrent sculpin. Numerous partially submerged logs and overhanging vegetation provide excellent habitats for smaller species and juveniles, not to mention ambush type predators such as rainbow trout, cutthroat trout, and largemouth bass. Unfortunately, the electroshocker could not be maneuvered to adequately sample these microhabitats. In spite of low numbers of fish caught, the number of species and species diversity were relatively high in Candiani secondary channel, which had fewer submerged logs and obstructions, making it possible to work the electroshocker closer to shore.

115. The species that were present in the secondary channels corresponded to a wide range of water velocities. Besides the northern squawfish and largescale sucker, the native species found in the secondary channels included peamouth, redside shiner, prickly sculpin, chiselmouth, rainbow trout, chinook salmon, and mountain whitefish. Introduced species included yellow bullhead, brown bullhead, and bluegill. These species may have been associated with slower waters along the shorelines or in the pools. Like the fish population at Candiani natural bank, the species composition in the secondary channels was dominated by the herbivorous largescale sucker and the omnivorous northern squawfish. Most of the other species rely on benthic invertebrates as a food source, except for chiselmouth which are herbivorous.

116. Benthic invertebrate densities in the secondary channels were relatively low compared to other habitat types. Diversities of taxa were relatively high in June compared to other locations, but declined in August when Fluminicola, Sphaeriidae, and Juga dominated the taxa compositions. These three taxa and Corbicula were more abundant in the secondary channels than in the other locations for both sampling periods. The cause of this distribution pattern may be related to the physical characteristics of the secondary channels such as fast, shallow water, gravel substrate, and increased proportions of shade. Pennak (1978) stated that Gastropoda and Pelecypoda are generally found in shallow aquatic habitats, but he believed the reason for this was related to food availability, which is generally higher at the shallower depths. Although the average depth of the secondary channels was generally less than that of the main river, the depths at the sampling stations were comparable because of their proximity to the shore (Table 3).

117. The benthic invertebrates in the secondary channels were primarily herbivorous, as they were at Five Island natural bank, which has a similar substrate and swift, shallow water. These herbivores include chironomids, grazers such as Flumincola and Juga, scrapers such as Protoptila and Glossosoma, net builders such as Hydropsyche and Cheumatopsyche, and the filter-feeding Sphaeriidae and Corbicula.

Abandoned Channel

118. The fish and invertebrate populations in Lambert Slough were the most unique among all locations. The biological difference is most likely the result of Lambert Slough's unique physical characteristics compared to the lotic habitats. The fish population was characterized by fish of large size, as indicated by the high total weight. In spite of low numbers and a low species diversity, several fish species were either unique to Lambert Slough or were most abundant there. This is reflected in the low similarity indices. The differences noted between the fish species composition of Lambert Slough and the lotic locations were consistent with the findings at reservoirs of the Columbia River (Hjort et al. 1981). Two of the predominant species in Lambert Slough, largescale sucker and northern squawfish, apparently have very broad water velocity preferences since they were found

in all of the locations of this study. Almost all of the other fishes in Lambert Slough, including largemouth bass, white crappie, black crappie, carp, bluegill, and warmouth, are introduced species. As a whole, these species prefer lentic habitat much like that found in Lambert Slough. The presence of overhanging shoreline vegetation and the logs and fallen trees in the water should provide good cover for bluegill and warmouth as well as for ambush predators such as the crappie species and largemouth bass. Silt bottoms are preferred by warmouth, black crappie, and carp, to name a few (Wydoski and Whitney 1979; Moyle 1976).

119. The fish community in Lambert Slough appears to be trophically more complex than those of the lotic habitats. In addition to the herbivorous largescale sucker and the omnivorous northern squawfish and carp, there are piscivorous largemouth bass, white crappie, black crappie, and channel catfish, and insectivorous bluegill and warmouth.

120. Lambert Slough supported the highest densities of benthic invertebrates of all the nonrevetted locations. The invertebrate population at Lambert Slough was very different from that of the other habitats in this study. Numerous taxa were most abundant in Lambert Slough or were found there exclusively. Lambert Slough was the location of least abundance for many taxa common to the other locations. In addition, the invertebrate composition in Lambert Slough was the least similar to the other locations (Table 16).

121. Differences in species composition between Lambert Slough and the lotic locations can be attributed to differences in water velocity, water quality (Tables 1 and 2), substrate composition, and organic content of the substrate (Appendix C). Many of the taxa that were most abundant in or exclusive to Lambert Slough are commonly associated with low water velocities. Among them are Caenis, Hexagenia, Ischnura, and Chironomus (Pennak 1978). Turbellaria and Isotomidae are associated with organic debris (Pennak 1978). Most of the widespread taxa that were absent from Lambert Slough were genera from Tricoptera or Ephemeroptera, which are usually associated with flowing water.

122. As with fish, the benthic invertebrate populations in Lambert Slough appear to be more complex trophically than those of the lotic locations. Most of the common invertebrates in the lotic locations were herbivores, with some scavengers at the revetments. The benthic

invertebrates at Lambert Slough included these two groups as well as numerous predators. Herbivores included Dubiraphia, Oecetis, Caenis, Gyraulus, and the filter-feeding Hexagenia. Scavengers included Turbellaria, Helobdella, and Asellus. Predatory taxa in Lambert Slough were Odonata, Sialis, Procladius, Hydracarina, and Chaoboridae. The Helobdella and Hydracarina may also be parasitic. Another common taxon in Lambert Slough was the particle-feeding oligochaetes.

Physical Impacts at Revetments

123. The total impact of revetments on the aquatic habitat is difficult to assess because this study lacked a true control: a stream with few or no revetments. It is difficult to determine whether or not cumulative impacts of many revetted banks affected the fauna at so-called "natural banks." The short-term effects, as determined from this study, may be beneficial for some aquatic fauna; however, the long-term effects may be detrimental (Stern and Stern 1980). The main short-term effects include increased densities of fish and benthic invertebrates and increased stability of aquatic habitat. Habitat stability is one of the factors contributing to the greater abundances of aquatic organisms at revetments (Solomon et al. 1975; Johnson et al. 1974; Menzel and Fierstine 1976). The presence of interstitial spaces and reduced water velocities may also be contributing factors. The instability of Candiani natural bank is a common occurrence in a river which meanders naturally. The lower fish and benthic invertebrate abundances and diversities at Candiani natural bank are probably the result of this instability and reflect a short-term loss as new habitat develops. Eventually, the erosion at Candiani natural bank should cease when the channel configuration is such that the river expends its energy evenly. When this occurs, the bank should stabilize and the abundance and diversity of aquatic organisms should increase. Revetments, on the other hand, should not be subject to the short-term fluctuations in abundances and diversity caused by habitat instability. Of course, there may be fluctuations in invertebrate densities at revetments due to other factors such as changes in flow. The density of benthic invertebrates was much lower at Weston revetment in August than it was in June.

124. The long-term effects of revetments include a reduction in the area and diversity of the aquatic habitat by restriction of the river channel (Johnson et al. 1974; Funk and Robinson 1974). Revetments are installed to reduce bank erosion and restrict movement of the river channel. This restriction is demonstrated in Figure 12, which shows the upper Willamette River as traced from two U. S. Geological Survey maps dated 1910 and 1967. This section of the Willamette River, from the McKenzie River to Harrisburg, had a highly braided channel in 1910. Construction of revetments in this section of the river began in 1938, and all of those completed by 1967 are shown in Figure 12.

125. Revetments appear to have been responsible for constraining and guiding the river into what is primarily a single channel. This has resulted in the loss of secondary channels and will reduce the long-term formation of abandoned channels. Secondary and abandoned channels add habitat area and diversity to a section of river. During the study period, for example, no water current flowed through Lambert Slough. As a result, Lambert Slough had the most unique fish and benthic invertebrate populations of all the locations.

126. The secondary channels also added habitat diversity because they had physical characteristics different from the main river. They were narrower and had a wider range of water velocities (Table 3). The secondary channels also had a higher proportion of shade because of the narrower stream width and overhanging vegetation. The natural bank locations and the secondary channels both had a wider range of water velocities, depths, and substrate types than the revetments, which were relatively homogeneous within and between locations.

127. Another long-term impact of revetments is the reduction of shallow water habitat. The steep shoreline gradient of the revetments reduces the width of the shallow water habitat that may be important to larval and juvenile fishes. Short-term loss of shallow water habitat occurs at eroding banks such as Candiani natural bank; however, the shallow water habitat should be reestablished when the erosion stops, allowing the bank to stabilize. Results from Hjort et al. (1981) indicate that the nearshore areas are important nursery habitats for larval fishes, and LaBolle (1983) has shown that the densities of larval fishes decrease with distance from

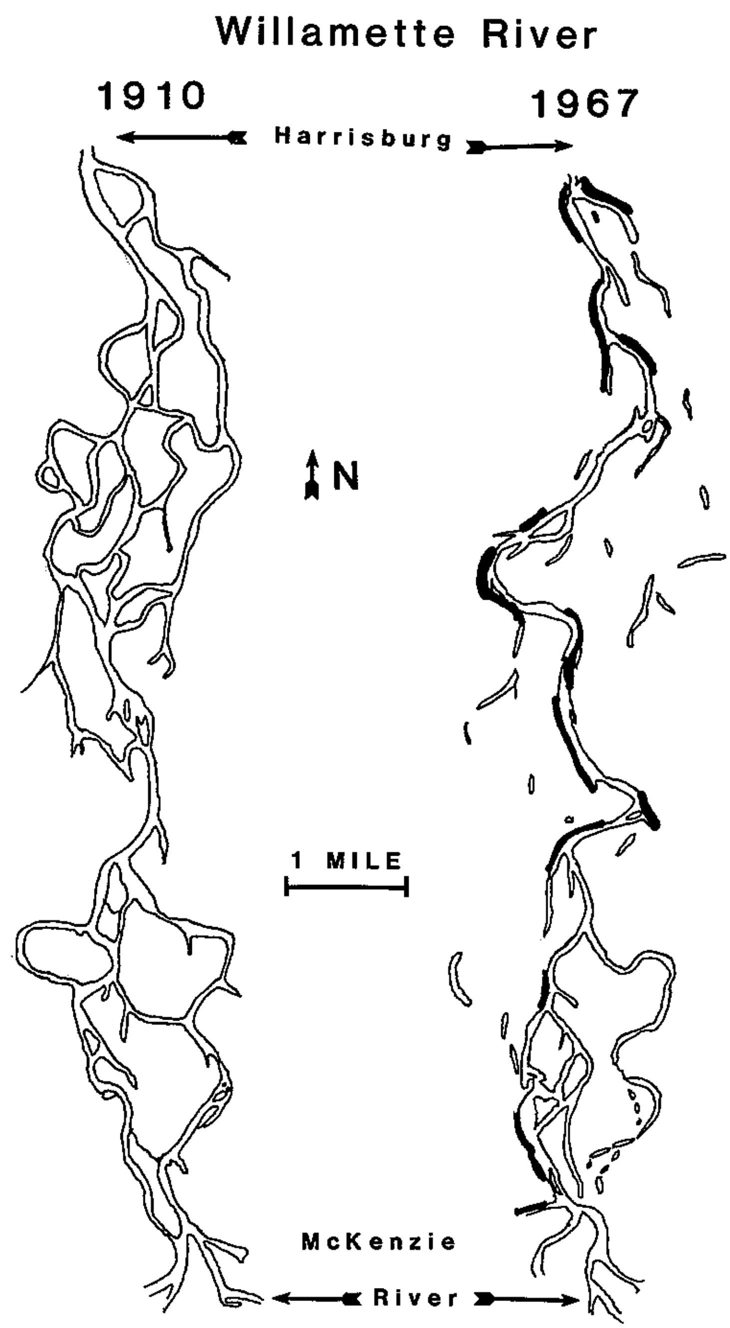

Figure 12. Outlines of the Willamette River between the mouth of the McKenzie River and Harrisburg, Oregon, as traced from U. S. Geological Survey maps surveyed in 1910 and 1967. The heavy lines on the 1967 map are revetments that were present before 1967. Direction of flow is to the north

shore within the nearshore area. The loss of the shallow water areas of revetments may be mitigated by moderate water velocities and the presence of interstitial spaces. The shallow water areas are also important spawning areas for some fish species. The large substrate and moderate water velocities at the revetments may not be suitable for fish species that require fast water and gravel substrate for spawning.

Individual Fish Species Distributions

128. Three basic fish species distribution patterns were observed: native species with general habitat preferences, native species with specific habitat preferences, and the introduced species. The first group includes the largescale sucker, northern squawfish, peamouth, and chiselmouth. These are large mobile fish that apparently have broad habitat preferences. Largescale suckers, for instance, dominated the catch totals at Candiani natural bank, Candiani secondary channel, and Lambert Slough. These habitats included both fine silt and gravel substrates, and water velocities ranging from 0 to 123 cm/sec. The habitat preferences of the other three species, although not as broad as the largescale sucker, were still widespread. Peamouth were collected in all habitat types but were not abundant enough to draw conclusions about habitat preferences. Northern squawfish and chiselmouth were both more abundant in the lotic habitats than in Lambert Slough.

129. The second group of native species had very specific distribution patterns. Several of these species are generally found in faster, cooler waters more common to the tributaries of the Willamette River. Among these species were cutthroat trout, rainbow trout, torrent sculpin, mountain whitefish, mountain sucker, and chinook salmon juveniles. Most of these fish were collected at Five Island natural bank, which had fast currents and shallow depths. Of the other native species with distinctive patterns of distribution, redside shiner and speckled dace were common to revetments, and leopard dace were most abundant at Five Island natural bank.

130. The introduced species were most abundant at Lambert Slough. They included largemouth bass, bluegill, warmouth, black crappie, and white crappie, which are commonly associated with lakes and ponds, habitats that are similar to Lambert Slough. The only introduced species that were more common in the lotic habitats were yellow bullhead and one smallmouth bass, which were collected at the revetments.

Patterns of Invertebrate Taxa Distribution

131. The composition of the invertebrate taxa varied greatly among locations. Obvious factors affecting distribution include differences in water velocity, substrate, depth, and organic detritus. The response of various taxa to patterns of water velocity, substrate, and organic detritus was discussed earlier. Undoubtedly, depth also plays a role, but it was not a major consideration of this study. The depth at each station was chosen to be comparable, except at Lambert Slough that had a more U-shaped cross section. However, it is difficult to determine what role depth played in the distribution of invertebrate organisms when comparing Lambert Slough to the other locations because differences in velocity and substrate confound the pattern.

132. Another factor which affects the distribution or organisms is high winter flows. The presence of overhanging vegetation in the secondary channels and Lambert Slough suggests that little winter scouring occurs there. Predominant taxa at natural banks were chironomids. These taxa were able to rapidly colonize an area or were able to exploit habitats deep in the substrate, thus protected from scouring and high water velocities. Predominant taxa at revetments were organisms that were attached to the substrate, such as *Manayunkia speciosa*, or were protected within the interstitial spaces, as was *Anisogammarus*. Predominant taxa in the secondary channels included *Juga* and Sphaeriidae, both of which could be dispersed by high water velocities and scouring. Lambert Slough was so different from the main river that its taxonomic assemblage was unique. Several of the predominant taxa were larger organisms, suggesting that they have longer life cycles and could not reestablish quickly if flushed out by high winter flows.

Comparisons with Past Studies

133. Twenty-eight fish species were captured during this study, including several not previously reported by Dimick and Merryfield (1945) or Noble (1952). These species were rainbow trout, mountain whitefish, smallmouth bass, channel catfish, warmouth, prickly sculpin, reticulate sculpin, and banded killifish. Dimick and Merryfield (1945) and Noble (1952) captured or reported 14 species each for a total of 21 species in their study areas, both located 6 miles upstream from the area of this study.

The only species they reported that was not collected in this study was the longnose dace (Rhinichthys cataractae).

134. There were several explanations for the greater species numbers captured in this study. First is the differences in gear types. Earlier workers relied primarily on seines and hook-and-line, compared to electroshocker and hoopnets used in this study. Data from one of our studies on Columbia River reservoirs suggest electroshockers will capture more species than seines (Hjort et al. 1981). Second, this study included several different habitat types (revetments, secondary channels, natural banks, and an abandoned channel) while the others were limited to areas where seines were most effective. Third, the Willamette River has undergone a dramatic change since the time of the previous studies (Gleeson 1972). At the time of the Dimick and Merryfield (1945) and Noble (1952) studies, the Willamette River had higher levels of pollutants and lower late-summer flow levels. Several of the species not captured before are sensitive to pollutants and may have been absent or less abundant during their studies. These species include prickly sculpin, reticulate sculpin, rainbow trout, mountain whitefish, and smallmouth bass. Another species captured in this study, the banded killifish, was added to Oregon's fish species list because it confirmed an earlier capture of this species*; thus, this species most likely was not formerly present.

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* Personal communication, 1982, Carl Bond, Professor, Department of Fisheries and Wildlife, Oregon State University.

PART V: SUMMARY

135. Revetments affect many aspects of fish habitat in the Willamette River including habitat diversity, abundance of benthic invertebrate prey, benthic community structure, water velocities, substrate size, total available habitat, and habitat stability. These factors determine, in part, the abundance, size, species diversity, and richness of fishes.

136. Impacts of the revetments are mixed. Higher densities of aquatic organisms were found at revetted sites, but species richness and diversity were not necessarily higher. Although not addressed in this study, casual observations indicate that revetments may provide good rearing habitat and protective cover because of the interstitial spaces and slower currents in these spaces. These characteristics may be especially important during high winter flows. A third benefit is an increase in habitat predictability/stability.

137. In theory, the fish and benthic invertebrate populations at revetments should be relatively stable from year to year compared to nonrevetted locations that might be subject to habitat degradation and change. An example of this problem was the low densities of fish and benthic invertebrates at Candiani natural bank where there was a severe erosion problem.

138. In spite of these benefits, the long-term impact of revetments on fish and invertebrate populations may be detrimental because revetments restrict channel movement and constrict the channel. Revetments eliminate the natural processes that result in multiple channels and abandoned channels. Thus, there is a potential for loss of total habitat area. However, estimates of the total losses of habitat compared to the increase in density of fishes and benthic invertebrates at the revetment sites are beyond the scope of this study.

REFERENCES

Bianchi, D. R., and Marcoux, R. 1975. "The Physical and Biological Effects of Physical Alterations of Montana Trout Streams and Their Political Implications," Symposium on Stream Channel Modification Proceedings, Harrisonburg, Va., 15-17 August 1975, pp 50-59.

Bierly and Associates, Inc. 1980. "Willamette Riverbank Stabilization Program: Vegetation Maintenance Demonstration Program," U. S. Army Corps of Engineers, Portland District.

Bond, C. E. 1973. Keys to Oregon Freshwater Fishes, Technical Bulletin 58, Oregon State University Agricultural Experiment Station, Corvallis, Oreg.

Britton, J. E. 1965. "A History of Water Pollution Control in the Willamette Basin, Oregon," Working Paper No. 56, U. S. Public Health Service, Portland, Oreg.

Bulkley, R. V., et al. 1976. "Warmwater Stream Alterations in Iowa. Extent, Effects on Habitat, Fish and Fish Food, and Evaluation of Stream Improvement Structures (Summary Report)," FWS/OBS-76-16, U. S. Fish and Wildlife Service, Washington, D. C.

Council on Environmental Quality. 1973. "Cleaning Up the Willamette River," Environmental Quality: The 4th Annual Report of the Council on Environmental Quality," Washington, D. C., pp 43-71.

Department of the Army. 1970. Laboratory Soils Testing, Engineer Manual EM 1110-2-1906, Corps of Engineers, Office of the Chief of Engineers.

Deval, B. 1977. "Draft Report, Willamette Recreation Study," Report to U. S. Army Corps of Engineers, Portland District.

Dimick, R. E., and Merryfield, F. 1945. The Fishes of the Willamette River System in Relation to Pollution, Engineering Experiment Station Bulletin Series No. 20, Oregon State University, Corvallis, Oreg.

Funk, J. L., and Robinson, J. W. 1974. Changes in the Channel of the Lower Missouri River and Effects on Fish and Wildlife, Aquatic Series No. 11, Missouri Department of Conservation, Jefferson City, Mo.

Gleeson, G. W. 1972. The Return of a River, WRRI-13, Advisory Committee on Environmental Technology and Water Resources Research Institute, Oregon State University, Corvallis, Oreg.

Gleeson, G. W., and Merryfield, F. 1936. Industrial and Domestic Wastes of the Willamette Valley, Bulletin Series No. 7, Engineering Experiment Station, Oregon State University, Corvallis, Oreg.

Green, R. H. 1979. Sampling Design and Statistical Methods for Environmental Biologists, Wiley, New York, N. Y.

Hansen, H. L. 1977. "Stock Assessment and Enhancement of Fall Salmon Species in the Willamette River System," Federal Aid Progress Reports--Fisheries, Oregon Department of Fish and Wildlife, Portland, Oreg.

Hjort, R. C., et al. 1981. "Habitat Requirements for Resident Fishes of the Lower Columbia River," Final Report to the Army Corps of Engineers, Portland, Oreg., Contract No. DACW57-79-C-0067.

Hunt, R. L. 1968. "Effects of Habitat Alteration on Production, Standing Crops, and Yield of Brook Trout in Lawrence Creek, Wisconsin," Division of Conservation, Wisconsin Department of Natural Resources, Waupaca, Wis.

Johnson, J. H., et al. 1974. "Environmental Analysis and Assessment of the Mississippi River 9-ft. Channel Project Between St. Louis, Missouri, and Cairo, Illinois," Technical Report Y-74-1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Keown, M. P., et al. 1977. "Literature Survey and Preliminary Evaluation of Streambank Protection Methods," Technical Report H-77-9, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Klingeman, P. C. 1973. Indications of Streambed Degradation in the Willamette Valley, WRRI-21, Water Resources Research Institute, Oregon State University, Corvallis, Oreg.

Klingeman, P. C., and Bradley, J. B. 1976. "Willamette River Streambank Stabilization by Natural Means," report prepared for the U. S. Army Corps of Engineers, Portland District.

LaBolle, L. D. 1984. Patterns of Nearshore Habitat Utilization by Larval Fishes in John Day Pool of the Columbia River, M.S. Thesis, Oregon State University, Corvallis, Oreg.

Menzel, B. W., and Fierstine, H. L. 1976. "A Study of the Effects of Stream Channelization and Bank Stabilization on Warmwater Sport Fish in Iowa: Subproject No. 5, Effects of Long-reach Stream Channelization on Distribution and Abundance of Fishes," FWS/OBS-76-15, U. S. Fish and Wildlife Service, Washington, D. C.

Moyle, P. B. 1976. Inland Fishes of California, University of California Press, Berkeley, Calif.

Mundie, J. H. 1971. "Sampling Benthos and Substrate Materials Down to 50 Microns in Size, in Shallow Streams," Journal of the Fisheries Research Board of Canada, Vol 28, pp 849-860.

Noble, R. E. 1952. The Willamette River Fishes as Biological Indicators of Pollution, M.S. Thesis, Oregon State University, Corvallis, Oreg.

Pennak, R. W. 1978. Fresh-water Invertebrates of the United States, Ronald Press Company, New York, N. Y.

Peters, J. C., and Alvord, W. 1963. "Man-made Channel Alterations in Thirteen Montana Streams and Rivers," Montana Fish and Game Department, Helena, Mont.

Shearman, J. O. 1976. "Reservoir System Needed for the Willamette River Basin, Oregon," Circular 715-H, U. S. Geological Survey, Arlington, Va.

Solomon, R. C., et al. 1975. "Environmental Inventory and Assessment of Navigation Pools 24, 25, 26, Upper Mississippi and Lower Illinois Rivers, Summary Report," Technical Report Y-75-1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Starbird, E. A. 1972. "A River Restored: Oregon's Willamette," National Geographic, Vol 141, No. 67, pp 817-834.

Stern, D. H., and Stern, M. S. 1980. "Effects of Bank Stabilization on the Physical and Chemical Characteristics of Streams and Small Rivers: An Annotated Bibliography," FWS/OBS-80-12, Office of Biological Services, U. S. Fish and Wildlife Service.

Thornber, C. H. 1965. "Bank Stabilization, Willamette and Columbia Rivers," Symposium on Channel Stabilization Problems, Technical Report No. 1, Vol 3, Committee on Channel Stabilization, U. S. Army Corps of Engineers, Vicksburg, Miss.

Thornber, C. H., and Bubenik, M. C. Unpublished and undated. "Channel Stabilization of the Willamette River," Mississippi River Commission, U. S. Army Corps of Engineers, Vicksburg, Miss.

U. S. Army Engineer District, Portland. 1975. "Willamette River Banks and Channels," Final Environmental Impact Statement, Portland, Oreg.

U. S. Fish and Wildlife Service. 1976. "Fish and Wildlife Management Plan for Sacramento River Bank Protection Project, California," U. S. Fish and Wildlife Service, Portland, Oreg.

Westgarth, W. C., and Northcraft, M. 1964. "Water Quality and Waste Treatment Needs for the Willamette River," Report of Oregon State Sanitary Authority, Salem, Oreg.

Willamette Basin Task Force. 1969. "Willamette Basin Comprehensive Study of Water and Land-related Uses," Pacific Northwest River Basins Commission, Vancouver, Wash.

Winger, R. V., et al. 1976. "Evaluation Study of Channelization and Mitigation Structures in Crow Creek, Franklin County, Tennessee, and Jackson County, Alabama," SCS Contract No. AG47 SCS-00141, Soil Conservation Service, U. S. Department of Agriculture, Nashville, Tenn.

Wydoski, R. S., and Whitney, R. R. 1979. Inland Fishes of Washington, University of Washington Press, Seattle and London.

BIBLIOGRAPHY

Baldwin, E. M. 1964. Geology of Oregon, Edward Bros., Ann Arbor, Mich.

Barton, J. R., et al. 1972. "The Effects of Highway Construction on Fish Habitat in the Weber River, Near Henefer, Utah," Ecological Impact of Water Resource Development, REC-ERC-72-17, D. A. Hoffman, coordinator, Bureau of Reclamation, Denver, Colo.

Beak Consultants. 1969. "Spawning Redd Studies," Report to American Can Company, Montreal, Quebec.

Becker, H. 1975. "Marine Patrol Study on Willamette River Use," Office of Sheriff, Benton County, Oreg.

Bond, C. E. 1974. Endangered Plants and Animals of Oregon; Vol I: Fishes, Special Report 205, Oregon State University Agricultural Experiment Station, Corvallis, Oreg.

Buchanan, D. V. 1975. "Willamette River Steelhead," Federal Aid Progress Reports--Fisheries, Oregon Department of Fish and Wildlife, Portland, Oreg.

Buchanan, D. V., Hooton, R. M., and Moring, J. R. 1981. "Northern Squawfish (Ptychocheilus oregonensis) Predation on Juvenile Salmonids in Sections of the Willamette River Basin, Oregon," Canadian Journal of Fisheries and Aquatic Sciences, Vol 38, No. 3, pp 360-364.

Chapman, D. W., and Bjornn, T. C. 1969. "Distribution of Salmonids in Streams with Special Reference to Food and Feeding," Symposium on Salmon and Trout in Streams, H. R. MacMillan Lectures in Fisheries, T. G. Northcote, ed., University of British Columbia, Vancouver, B. C.

Collins, M. D. 1974. "Escapement of Salmon and Steelhead over Willamette Falls, Winter and Spring 1973," Fish Commission of Oregon, Clackamas, Oreg.

Craig, J. A., and Townsend, L. D. 1946. An Investigation of Fish Maintenance Problems in Relation to the Willamette Valley Project, Special Scientific Report No. 33, Fish and Wildlife Service, U. S. Department of the Interior, Portland, Oreg.

Deschamp, G. 1952. Bio-indices of Pollution in the Willamette River, M.S. Thesis, Oregon State University, Corvallis, Oreg.

Everson, L. B. 1974. "Biological Survey of the Willamette River, August-October 1973," Beak Consultants Report to the American Can Company, Montreal, Quebec.

Fish Commission of Oregon. 1969. "Potential for Increased Natural Production of Willamette River Salmon and Steelhead," Informational Report, Clackamas, Oreg.

Fish, F. F., and Imler, R. 1948. "Willamette Valley Project, Oregon: Preliminary Evaluation Report on Fish and Wildlife Resources," Fish and Wildlife Service, U. S. Department of the Interior, Portland, Oreg.

Fish, F. F., and Rucker, R. R. 1950. "Pollution in the Lower Columbia Basin in 1948 with Particular Reference to the Willamette Basin," Special Fisheries Scientific Report No. 30, Fish and Wildlife Service, U. S. Department of the Interior, Portland, Oreg.

Fish, F. F., and Wagner, R. A. 1950. "The Formation and Lifting of Oxygen Block in the Mainstem Willamette River," Special Fisheries Scientific Report No. 41, Fish and Wildlife Service, U. S. Department of the Interior, Portland, Oreg.

Gleeson, G. W. 1936. A Sanitary Survey of the Willamette River from the Sellwood Bridge to the Columbia River, Bulletin Series No. 6, Engineering Experiment Station, Oregon State University, Corvallis, Oreg.

Gorman, O. T., and Kass, J. R. 1978. "Habitat Structure and Stream Fish Communities," Ecology, Vol 59, No. 3, pp 505-515.

Hansen, E. A. 1971. "Sediment in a Michigan Trout Stream: Its Source, Movement and Some Effects on Fish Habitat," Forest Service Research Paper NC-59, U. S. Department of Agriculture, North Central Forest Experiment Station, St. Paul, Minn.

Hansen, H. L. 1976. "Willamette River Development Program," Federal Aid Progress Reports--Fisheries, Oregon Department of Fish and Wildlife, Portland, Oreg.

Harris, D. D. 1968. Travel Rates of Water for Selected Streams in the Willamette River Basin, Oregon, U. S. Geological Survey Hydrologic Investigations Atlas HA-273.

Hines, W. G., Rickert, D. A., and McKenzie, S. W. 1976. "Hydrologic Analysis and River Quality Data Programs," U. S. Geological Survey Circular 715-D, Arlington, Va.

Hines, W. G., et al. 1977. Dissolved Oxygen Regimen of the Willamette River, Oregon, Under Conditions of Basinwide Secondary Treatment, U. S. Geological Survey Circular 715-I, Arlington, Va.

Hoerauf, E. A. 1970. Willamette River: River Lands and River Boundaries, WRRI-1, Water Resources Research Institute, Oregon State University, Corvallis, Oreg.

Honey, W. D., Jr. 1975. The Willamette River Greenway: Cultural and Environmental Interplay, WRRI-35, Water Resources Research Institute, Oregon State University, Corvallis, Oreg.

Huff, E. S., et al. 1976. Restoring the Willamette River: Costs and Impacts of Water Quality Control, EPA 600/5-76-005, Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, Ga.

Hunt, W. A., and Graham, R. J. 1972. "Preliminary Evaluation of Channel Changes Designed to Restore Fish Habitat," Department of Civil Engineering and Engineering Mechanics and Cooperative Fisheries Unit, Montana State University, Bozeman, Mont.

Hutchison, J. M., and Aney, W. W. 1963. "The Fish and Wildlife Resources of the Middle Willamette Basin, Oregon, and Their Water Use Requirements," Report to the Water Resources Board, Oregon State Game Commission, Basin Investigation Section, Portland, Oreg.

__________. 1964. "The Fish and Wildlife Resources of the Lower Willamette Basin, Oregon, and Their Water Use Requirements," Oregon State Game Commission Report, Portland, Oreg.

Hutchison, J. M., Thompson, K. E., and Fortune, J. D., Jr. 1966. "The Fish and Wildlife Resources of the Upper Willamette Basin, Oregon, and Their Water Use Requirements," Oregon State Game Commission, Portland, Oreg.

Kallemeyn, L. W., and Novotny, J. F. 1977. "Fish and Fish Food Organisms in Various Habitats of the Missouri River in South Dakota, Nebraska, and Iowa," FWS/OBS-77-25, U. S. Fish and Wildlife Service, Washington, D. C.

Knight, M. C. 1971. "Biological Survey of the Willamette River, June 1970," Beak Consultants Report to the American Can Company, Montreal, Quebec.

Knight, M. C., and Hodd, S. C. 1971. "Spawning Redd Studies, Willamette River, 1970," Beak Consultants Report to the American Can Company, Montreal, Quebec.

Koon, R. E. 1936. "Stream Cleansing in Oregon, Past and Present Efforts to Reduce Pollution," Civil Engineering, Vol 6, No. 10.

Koon, R. E., Cunningham, J. W., and Dieck, R. G. 1933. "Report on General Survey of the Problems of Sewage Treatment and Disposal in the Willamette River Valley, Oregon," Submitted to Julius L. Meier, Governor of Oregon, and the Reconstruction Advisory Board by the Board of Consulting Engineers on Sewage Disposal, Salem, Oreg.

Koon, R. E., and Merryfield, F. 1937. "A Preliminary Survey of Industrial Pollution in Oregon Streams," Report by Advisory Committee on Stream Purification and Subcommittee on Present Stream Conditions to Oregon State Planning Board, Salem, Oreg.

Larrimore, R. W., and Smith, R. W. 1963. "The Fishes of Champaign County, Illinois, as Affected by 60 Years of Stream Changes," Illinois Natural History Survey Bulletin, Vol 28, No. 2, pp 295-382.

Lund, J. A. 1976. "Evaluation of Stream Channelization and Mitigation on the Fisheries Resources of the St. Regis River, Montana," FWS/OBS-76-07, U. S. Fish and Wildlife Service, Washington, D. C., and Cooperative Fishery Research Unit, Montana State University, Bozeman, Mont.

Madison, R. J. 1963. "River Mile Index, Willamette River," Hydrology Subcommittee, Columbia Basin Interagency Committee, Portland, Oreg.

__________. 1966. "Water Quality Data in the Willamette Basin," U. S. Department of the Interior, U. S. Geological Survey Basic Data Release.

Merritt, R. W., and Cummins, K. W. 1978. An Introduction to the Aquatic Insects of North America, Kendall Hunt Publishing Co., Dubuque, Iowa.

Merryfield, F. 1936. "Stream Cleaning in Oregon, Industrial Wastes in the Willamette Valley." Civil Engineering, Vol 6, No. 10.

Merryfield, F., and Wilmot, W. G. 1945. "Progress Report on Pollution of Oregon Streams," Engineering Experiment Station Bulletin Series No. 19, Oregon State University, Corvallis, Oreg.

Needham, P. R., et al. 1948. "Fish and Wildlife Problems Arising from the Willamette Valley Project," Evaluation Report, Oregon State Game Commission and Fish Commission of Oregon, Portland, Oreg.

Oregon Department of Environmental Quality. (annual). "Water Quality Control in Oregon," Portland, Oreg.

Oregon State Water Resources Board. 1961. "Middle Willamette Basin Survey of the Literature," Salem, Oreg.

Oregon State Water Resources Board. 1961. "Upper Willamette Basin," Salem, Oreg.

Oregon State Water Resources Board. 1963. "Middle Willamette Basin," Salem, Oreg.

Oregon State Water Resources Board. 1965. "Lower Willamette Basin," Salem, Oreg.

Oregon State Water Resources Board. 1967. "Willamette River Basin," Salem, Oreg.

Oregon State Water Resources Board. 1969. "Oregon's Long-range Requirements for Water, General Soil Map Report with Irrigable Areas, Willamette Drainage Basin," Appendix 1-2, Salem, Oreg.

Oster, E. A. 1968. Patterns of Runoff in the Willamette River Basin, Oregon, U. S. Geological Survey Hydrologic Investigation Atlas HA-274.

Otis, M. B. 1974. "Stream Improvement," The Stream Conservation Handbook, J. M. Misel, ed., Crown Publishers, New York, pp 99-122.

Parkhurst, Z. E., Bryant, F. G., and Nielson, R. S. 1950. Survey of the Columbia River and Its Tributaries, Part III. Special Scientific Report: Fisheries, No. 36, U. S. Fish and Wildlife Service, Portland, Oreg.

Quigley, J. M. 1967. "Willamette River Basin Water Quality Control and Management," NTIS PB-215 923, Federal Water Quality Control Administration, Portland, Oreg.

Rickert, D. A., and Hines, W. G. 1975. "A Practical Framework for River Quality Assessment," U. S. Geological Survey Circular 715-A, Arlington, Va.

__________. 1978. "River Quality Assessment: Implications of a Prototype Project," Science, Vol 200, No. 4326, pp 1113-1118.

Rickert, D. A., Hines, W. G., and McKenzie, S. W. 1975. "Planning Implications of Dissolved-oxygen Depletion in the Willamette River, Oregon," W. Whipple, Jr., ed., Urbanization and Water-quality Control: Minneapolis, American Water Resources Association, pp 70-84.

Rickert, D. A., et al. 1977. A Synoptic Survey of Trace Metals in Bottom Sediments of the Willamette River, Oregon, U. S. Geological Survey Circular 715-F, Arlington, Va.

Rogers, H. S., Mockmore, C. A., and Adams, C. D. 1930. A Sanitary Survey of the Willamette Valley, Engineering Experiment Station Bulletin Series No. 2, Oregon State University, Corvallis, Oreg,

Sainsbury, J. B. 1970. "Benthal Deposits of the Willamette River, Oregon," Department of Environmental Quality Report, Portland, Oreg.

Sams, R. E. 1973. "Willamette River Development Program: Annual Progress Reports," Fish Commission of Oregon, Clackamas, Ore.

__________. 1974. "Willamette River Development Program: Annual Progress Reports," Fish Commission of Oregon, Clackamas, Oreg.

Sams, R. E., and Conover, K. R. 1969. "Water Quality and the Migration of Fall Salmon in the Lower Columbia River," Fish Commission of Oregon, Portland, Oreg.

Schuytema, G. S. 1972. "American Can Company, Halsey Mill, Biological Survey, Willamette River," Memorandum to Ralph H. Scott of the Paper and Forest Industry.

Smith, E. M. 1976. "Rearing Spring Chinook in Willamette River Reservoirs," Federal Aid Progress Reports--Fisheries, Oregon Department of Fish and Wildlife, Portland, Oreg.

__________. 1980. "Bibliography: Willamette Spring Chinook Salmon Adults," Oregon Department of Fish and Wildlife Information Report Series: Fisheries, No. 80-3.

Stone, D. 1967. "Progress Report on Biological Pre-operational Surveys of the Willamette River in Connection with Halsey Pulp Mill," Beak Consultants Report to American Can Company, Halsey, Oreg.

__________. 1968. "Biological Surveys of Willamette River in Connection with Halsey Pulp Mill," Beak Consultants Report to American Can Company, Halsey, Oreg.

__________. 1969. "1968 Biological Surveys of Willamette River in Connection with Halsey Pulp Mill," Beak Consultants Report to American Can Company, Halsey, Oreg.

Swift, C. H., III. 1966. "Selected Flow Characteristics of Streams in the Willamette River Basin, Oregon," Water Resources Division, U. S. Department of Geological Survey.

Thompson, K. E., et al. 1966. "Fish Resources of the Willamette Basin," Oregon State Game Commission, Portland, Oreg.

U. S. Environmental Protection Agency. (Undated). "A Water Quality Success Story, the Willamette River Lives Again," Environmental Protection Agency, Seattle, Wash.

U. S. Fish and Wildlife Service. 1950. Oxygen Block in the Mainstem Willamette River, Special Scientific Report: Fisheries, No. 41.

Velz, C. J. 1951. "Report on Natural Purification Capacities, Willamette River: National Council for Stream Improvement of the Pulp, Paper, and Paperboard Industries, Inc.," School of Public Health, Michigan University, Ann Arbor, Mich.

__________. 1961. "Supplementary Report on Lower Willamette River Waste Assimilation Capacity: National Council for Stream Improvement of the Pulp, Paper, and Paperboard Industries, Inc.," School of Public Health, Michigan University, Ann Arbor, Mich.

Weber, K. G., and Schedin, L. G. 1952. Water Temperatures of the Willamette River System 1950, Special Scientific Report: Fisheries, No. 69. U. S. Fish and Wildlife Service, Portland, Oreg.

White, R. J., and Brynildson, O. M. 1967. Guidelines for Management of Trout Stream Habitat in Wisconsin, Technical Bulletin No. 39, Wisconsin Department of Natural Resources, Division of Conservation, Madison, Wis.

Willis, R. A., Collins, M. D., and Sams, R. E. 1960. "Environmental Survey Report Pertaining to Salmon and Steelhead in Certain Rivers of Eastern Oregon and the Willamette River and Its Tributaries," Fish Commission of Oregon, Portland, Oreg.

Witten, A. L., and Bulkley, R. V. 1975. "A Study of the Effects of Stream Channelization and Bank Stabilization on Warmwater Sports Fish in Iowa: Subproject No. 2, A Study of the Impact of Selected Bank Stabilization Structures on Game Fish and Associated Organisms," FWS/OBS-76-12, U. S. Fish and Wildlife Service, Washington, D. C.

Workman, P. C. 1974. "Evaluation of Stream Improvements in Prickly Pear Creek, 1971-1973," Montana Project Nos. F-9-R-19, F-9-R-20, F-9-R-21, F-9-R-22, Job II-a, Montana State Fish and Game Commission, Grand Falls, Mont.

APPENDIX A: FISH CATCHES FROM ELECTROSHOCKING AND HOOPNET SETS ON RIVER MILES 58-66 OF THE WILLAMETTE RIVER, OREGON, JUNE AND AUGUST 1982

Table A1. Catch by species of fish collected by electroshocking 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 9-11, 1982.

	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
Species	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																				1	
Northern squawfish	28	32	23	18	7	8	4	9			2				5	1	2	7		1	2
Peamouth														1			1	2		1	
Chiselmouth	7	4	3	6	2	1						1		2	1		1	4			
Largescale sucker	9	6	6	9	3	1	5	3		12	4	13	2	4	5	5	12	9	22	4	5
Mountain sucker							4	6			1										
Redside shiner			4		2	2				1		2									
Speckled dace	1	1	3	1	3	4	2		4												
Leopard dace							6	4	59												
Mountain whitefish							3														
Chinook salmon				1	1					1		1	1	1			1				
Rainbow trout					1	1										1					
Cutthroat trout								2													
White crappie																			2	1	1
Smallmouth bass	1																				
Largemouth bass										1									3	3	6
Bluegill																					1
Channel catfish																				1	
Yellow bullhead						1															
Prickly sculpin	7	4	7	2	10	9		1										1			
Torrent sculpin							2		6												
Reticulate sculpin	3		1	1	1																
Banded killifish					1																
Totals																					
No. Individuals	56	47	47	38	31	27	26	25	69	15	7	17	3	8	11	7	17	23	27	12	15
No. Species	7	5	7	7	10	8	7	6	3	4	3	4	2	4	3	3	5	5	3	7	5

Table A2. Catch by species of fish collected by electroshocking 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, August 23-25, 1982.

	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
Species	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																			1	1	
Northern squawfish	35	43	22	32	47	36	18	6	15	8	7	13	2	7	8	4	1	4	1	1	
Peamouth	1	1									1					1	2				
Chiselmouth	1		2	9	5	2	20	2	1			2									
Largescale sucker	2		3	4	3	3	2	3	2	7	5	5	3	2	2	6	6	9	12	3	4
Mountain sucker							1	5					1								
Redside shiner	8	2	3	5	9	6						1				3	1				
Speckled dace				2		2															
Leopard dace								1	4		1										
Mountain whitefish								5	3				2				2	2			
Chinook salmon							1														
Largemouth bass																			1	2	2
Yellow bullhead						1															
Prickly sculpin	12	3	1	1	1	6															
Torrent sculpin								1													
Reticulate sculpin	1	1																			
Totals																					
No. Individuals	60	50	31	53	65	56	42	23	25	15	14	21	8	9	10	14	12	15	15	7	6
No. Species	7	5	5	6	5	7	5	7	5	2	4	4	4	2	2	4	5	3	4	4	2

Table A3. Catch by species of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 7-8, 1982.

	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
Species	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Northern squawfish	2					4								5	2	1	2	2	1									
Chiselmouth							1	1							1			1										
Largescale sucker					1	2		2				1		10	1		4	2	2		1							
Black crappie																				1							1	
White crappie																											2	2
Bluegill									1	1				1	1						1					2		11
Pumpkinseed										1																		
Warmouth																										2		3
Brown bullhead																								1				
Yellow bullhead																					2							
Lamprey	2																											
Totals																												
No. Individuals	4				1	6	1	3	1	2		1		16	5	1	6	5	3	1	4			1		4	3	16
No. Species	2				1	2	1	2	1	2		1		3	4	1	2	3	2	1	3			1		2	2	3

Table A4. Catches by species of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 of the Willamette River, Oregon, August 16-20, 1982.

	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Carp														1														
Northern squawfish	3	3				1	2	5	1					6	1	3	1				2	1	1			1		
Chiselmouth	1	1	1	7	2			3			1	1		9														
Largescale sucker	1			1		1	2	2	1		1			3	1							1			1	3		
Black crappie														1												2		
White crappie																									1	5		1
Bluegill						1																				9		4
Warmouth																										1		
Yellow bullhead					1	2	1	1							1							1						
Totals																												
No. Individuals	5	4	1	8	3	5	5	11	2		2	1		20	3	3	1				2	3	1		2	21		5
No. Species	3	2	1	2	2	4	3	3	2		2	1		5	3	1	1				1	3	1		2	6		2

Table A5. Total weight (gms) by species of fish collected by electroshocking 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 9-11, 1982.

	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
Species	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																				1660	
Northern squawfish	2648	2947	2852	2442	621	1288	187	536			484				1252	248	295	2019		10	19
Peamouth														310			275	443		7	
Chiselmouth	1075	350	474	612	56	200						115		252	19		233	465			
Largescale sucker	3016	1383	2195	3635	1835	170	1207	1780		6169	2430	7117	1500	1925	3740	2568	7500	5408	12,759	3130	2795
Mountain sucker							23	71			157										
Redside shiner			149		38	52				34		27									
Speckled dace	2	3	5	1	6	7	11		4												
Leopard dace							6	5	58												
Mountain whitefish							4														
Chinook salmon				10	14					10		3400		54			15				
Rainbow trout				95	100											3900					
Cutthroat trout								144													
White crappie																			405	175	105
Smallmouth bass	5																				
Largemouth bass										228									2672	200	361
Bluegill																					25
Channel catfish																				5200	
Yellow bullhead						175															
Prickly sculpin	89	56	104	14	120	227		4										5			
Torrent sculpin							18		43												
Reticulate sculpin	15		4	3	2																
Banded killifish					2																
TOTALS																					
Total weight	6850	4739	5783	6717	2789	2219	1456	2540	105	6441	3071	10,659	1500	2541	5011	6716	8318	8340	15,836	10,382	3305
No. Species	7	5	7	7	10	8	7	6	3	4	3	4	1	4	3	3	5	5	3	7	5

Table A6. Total weight (gms) by species of fish collected by electroshocking 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, August 23-25, 1982.

	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
Species	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																			1000	2560	
Northern squawfish	423	373	739	1884	1925	1110	313	70	102	1834	38	3546	647	885	1730	794	27	2527	55	142	
Peamouth	94	3									303					105	222				
Chiselmouth	205		530	581	819	25	267	41	8			330									
Largescale sucker	2000		2300	1850	1320	1538	828	1885	6	5750	3535	3405	2025	1425	1550	2765	4019	6685	7370	1290	765
Mountain sucker							27	100					135								
Redside shiner	68	18	25	141	94	126						49				34	7				
Speckled dace				7		4															
Leopard dace								3	13		4										
Mountain whitefish								65	23				30				35	24			
Largemouth bass																			2	361	959
Yellow bullhead						320															
Prickly sculpin	150	52	22	6	29	169															
Torrent sculpin								22													
Reticulate sculpin	4	7																			
TOTALS																					
Total weight	2944	453	3616	4469	4187	3292	1435	2186	152	7584	3880	7330	2837	2310	3280	3698	4310	9236	8427	4353	1724
No. Species	7	5	5	6	5	7	4	7	5	2	4	4	4	2	2	4	5	3	4	4	2

Table A7. Total weight (gms) by species of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 7-9, 1982.

	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
Species	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Northern squawfish	1230					1707								1459	1307	1020	1672	1765	300									
Chiselmouth							173	175							310			265										
Largescale sucker					695	385		148				135		4003	620		2515	1115	960		920							
Black crappie																				165							85	
White crappie																											308	168
Bluegill									90	135				115	75						94					114		858
Pumpkinseed										37																		
Warmouth																										177		363
Brown bullhead																								248				
Yellow bullhead																					315							
Pacific lamprey	795																795											
TOTALS																												
Total weight	2025	0	0	0	695	2092	173	323	90	172	0	135	0	5577	2312	1020	4187	3145	1260	165	1229	0	0	248	0	291	393	1389
No. Species	2	0	0	0	1	2	1	2	1	2	0	1	0	3	4	1	2	3	2	1	3	0	0	1	0	2	2	3

Table A8. Total weight (gms) of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 on the Willamette River, Oregon, August 16-20, 1982.

	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
Species	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Carp														1500											1500			
Northern squawfish	855	1465				300	1750	1027	125					3120	395	1995	200				500	650	625			155		
Chiselmouth	110	200	110	1313	250			357			230	90		1520														
Largescale sucker	495			280		110	1050	950	165		330			1635	200							450			510	1050		
Black crappie														220												148		
White crappie																									120	562		80
Bluegill						90																				528		330
Warmouth																										39		
Yellow bullhead					250	575	300	165							240							175						
TOTALS																												
Total weight	1460	1665	110	1593	500	1075	3100	2499	290	0	560	90	0	7995	835	1995	200	0	0	0	500	1275	625	0	630	2482	0	410
No. Species	3	2	1	2	2	4	3	4	2	0	2	1	0	5	3	1	1	0	0	0	1	3	1	0	2	6	0	2

Table A9. Total number of individual fish, total number of species and total weight (grams) for electroshocker and hoopnet catches on the Willamette River, June and August 1982.

	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Total No. Individuals	313	305	219	137	65	99	133
Total No. Species	10	12	13	13	8	12	10
Total Weight	31,238	34,130	17,723	58,545	26,436	44,495	49,212

Table B1. Numbers by taxa of invertebrates identified from benthic samples taken at 28 stations within seven habitats between river miles 58 and 66 of the Willamette River, Oregon, June, 1982. Dashes (-) in the station columns denote invertebrate taxa that were only collected during the August sampling period.

PHYLUM / CLASS / ORDER / Family / Genus, species	Revetted Banks								Natural Banks							
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
PLATYHELMINTHES																
TURBELLARIA	-								-							
NEMATODA	1				20	9	6									
NEMATOMORPHA	30	62	83	78	80	37	19	25	17	37	9	23	36	6	13	8
ANNELIDA																
OLIGOCHAETA	552	1407	282	240	2071	1490	562	650	116	57	104	136	163	10	160	12
BRANCHIOBDELLIDA	5		97		209		6					1				
POLYCHAETA																
Sabellidae																
Manayunkia speciosa	166	561	844	835	547	927	238	3575					3			
HIRUDINEA																
Erpobdellidae																
Erpobdella	-								-							
Dina																
Glossiphonidae																
Placobdella	-								-							
Helobdella												2				
ARTHROPODA																
CRUSTACEA																
OSTRACODA		1														
ISOPODA																
Asellidae																
Asellus																
AMPHIDODA																
Gammaridae																
Anisogammarus	90	3477	1837	3494	3990	769	818	2712	3	3		5	20	2	4	
Talitridae																
Hyalella azteca			8	37	50											
DECAPODA																
Astacidae																
Pacifastacus leniusculus	31	16	20	17	11	2	8	33								
ARACHNOIDEA																
HYDRACARINA																
Lebertiidae																
Lebertia	7	25	8			37	7	33				3		2	2	
Torrenticolidae																
Torrenticola	1															
Arrenuridae																
Arrenurus																
Mideopsidae			.													
Mideopsis	-								-							

PHYLUM / CLASS / ORDER / Family / Genus, species	Secondary Channels								Abandoned Channel			
	Five Island Bar				Candiani Bar				Lembert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D
PLATYHELMINTHES												
TURBELLARIA	-								-			
NEMATODA									36	12		
NEMATOMORPHA	2	7	15	33	14	15	113	7	19	12		7
ANNELIDA												
OLIGOCHAETA	10	521	61	730	173	88	1438	24	1086	244	3899	711
BRANCHIOBDELLIDA		4						2				
POLYCHAETA												
Sabellidae												
Manayunkia speciosa		43	2		14	7	56					
HIRUDINEA												
Erpobdellidae												
Erpobdella	-								-			
Dina		4										
Glossiphonidae												
Placobdella	-								-			
Helobdella	-	4									438	21
ARTHROPODA												
CRUSTACEA												
OSTRACODA												
ISOPODA												
Asellidae												
Asellus											269	7
AMPHIDODA												
Gammaridae												
Anisogammarus	10	18	9	19	75	10		23				
Talitridae												
Hyalella azteca										12	5	
DECAPODA												
Astacidae												
Pacifastacus leniusculus												
ARACHNOIDEA												
HYDRACARINA												
Lebertiidae												
Lebertia						5	28					
Torrenticolidae												
Torrenticola												
Arrenuridae												
Arrenurus										12		
Mideopsidae												
Mideopsis	-								-			

(Continued)

Table B1. Continued

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Scoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Unionicolidae																												
Unionicola				12																						24	24	
Pionidae																												
Forelia																				31			28			73		21
Piona																											75	
Sperchonidae																												
Sperchon	1	12										2							5					2				
Aturidae																												
Aturus	2		2	25																								
Hygrobatidae																												
Hygrobates	1																											
Atractides					10							2							1				28	2				
Anystidae																												
Anystis												1																
INSECTA																												
COLLEMBOLA																												
Isotomidae	-								-								-								-			
PLECOPTERA																												
Nemouridae																												
Zapada		12																										
Perlidae																												
Classenia													1															
EPHEMEROPTERA																												
Leptophlebiidae																												
Paraleptophlebia	39	38	4			9		17							2													
Ephemeridae																												
Hexagenia																										1		50
Serratella	9	75	29	75	10	37		41	3			4	3					4			5	2						
Tricorythidae																												
Tricorythodes	8	37	27	12	20			25	10			4	10	2				1		12			28					
Caenidae																												
Caenis																											24	7
Ephemerellidae																												
Ephemerella	2	50	4	12	30		7					4	2					7	7		5							
Heptageniidae																												
Eperorus																					5							
Rhithrogena											24	1																
Stenonema	36	2	15	12	10	19	30	25		1		6		2				18	2									
Heptagenia			2			19		17				11						14			23							
Baetidae																												
Centroptilum	38	25					68						3						12									
Baetis	2	12													4													
Pseudocloeon	5	12	6	25			6	8		2	6	35				4	4		16		14			2				

(Continued)

(Sheet 2 of 3)

APPENDIX B: BENTHIC INVERTEBRATE DENSITIES FROM SAMPLES COLLECTED FROM RIVER MILES 58-66 OF THE WILLAMETTE RIVER, OREGON, JUNE AND AUGUST 1982

Table B1. Continued

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
ODONATA																												
Coenagriidae																												
<u>Ischnura</u>																											1	
HOMOPTERA	-								-								-								-			
MEGALOPTERA																												
Sialidae																												
<u>Sialis</u>																											53	14
NEUROPTERA																												
Sisyridae																												
<u>Sisyra</u>																										12		
<u>Climacia</u>						9																				25		
TRICOPTERA (pupae)	7	29	62	41		13	33	71		6	3				3		4	5	2		5			10				
Hydropsychidae																												
<u>Hydropsyche</u>	12	53	16	55	30	44		6		1		2					1				9							
<u>Cheumatopsyche</u>	45	100	52	176	10	37	26	101		2								4	2		5			2				
Hydroptilidae																												
<u>Leucotrichia</u>	1																											
<u>Hydroptila</u>	20	15	8	24		37	7	8																				
Leptoceridae																												
<u>Oecetis</u>																											24	
<u>Ceraclea</u>	2		4					8											2									
Glossosomatidae																												
<u>Glossosoma</u>											3						2	11	7		28			7				
<u>Protoptila</u>																		14	11									
Psychomyiidae																												
<u>Psychomyia</u>	4		2	37																								
Polycentropodidae																												
<u>Polycentropus</u>	-								-								-								-			
Brachycentridae																												
<u>Brachycentrus</u>	-								-								-								-			
Lemnephilidae																												
<u>Dicosmoecus</u>										1																		
LEPIDOPTERA																												
Pyralidae																												
<u>Parargyractis</u>	14	58	44	55	20	10	8																					
COLEOPTERA																												
Elmidae																												
<u>Dubiraphia</u> (larvae)						9												4					84		55	75	122	213
<u>Dubiraphia</u> (adult)																											24	
<u>Optioservus</u> (larvae)										1						2			2									
DIPTERA																												
Tipulidae (pupae)						9																						
<u>Antocha</u>								8																				
Chaoboridae	-								-								-								-			

(Sheet 3 of 5)

Table B1. Continued

PHYLUM / CLASS / ORDER / Family / Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Simuliidae (pupae)	-								-								-								-			
Simulium (larvae)											3														2			
Empididae																									2			
Hemerodromia (larvae)	1		2		10	9																						
Hemerodromia (pupae)	1	12				9		8																		1		
Ephydridae (larvae)																			2				28	2				
Ceratopegonidae																												
Bezzia-Probezzia	2																		2	6					36		49	21
Palpomyia										10	12	14	7		6	2	6		5		14	7		14				
Chironomidae (pupae)	151	178	180	174	368	254	193	166	30	47	109	211	36	6	27	15					19	40		14				7
Rheotanytarsus	117	168	193	551	262	506	21	265	13		67	343	158	8	35	6		21	10		14		76	11				
Cricotopus		1		42		36	42				1		23	12	3					25	9			2				
Eukiefferiella				42		36				8	94	76		4	3			14	13		9	3		3			26	
Synorthocladius			32														2	7	13		19		76					
Paratanytarsus	846	933	647	634	383	470	334	239	211	74	9	229	192	29	59	21		18			14	53						17
Orthocladius-Cricotopus	146	985	386	636	523	434	229	292	251	313	245	877	124	41	59	79	4	39	15		14	43	152	25				
Endochironomus	88				261		42		66					4	3	2		12		406	5	20	2438	2		12	81	17
Dicrotendipes	117	328	131	84	120	289	250	398	79	8		38			3			15	5	25		13					55	51
Nanocladius	58	56	32	84	75	36	104													25								
Stenochironomus					1		21																					
Tanytarsus	58	109	32	85	148			27	26			38	34		3	4			14	76	30		76	2		12	210	34
Polypedilum			97	1	1			53	26	16	66	191	11		3	4	4	7	10	51		1	152	11			52	34
Chironomus		1			37															592			717	2	173	1	2	17
Thienemanniella		3									9	114	11				2							5				
Procladius				1		36														76					18	319	251	562
Micropsectra					37								11			2											1	
Paracladopelma																2		4		2			76					
Cryptochironomus																							76				1	
Potthastia	29	55	32	2				27				38	11		3	2												
Cladopelma																										12	29	68
Rheocricotopus		54		42			21																	2				
Brillia	58				2			27											3					2			1	
Ablabesmyia			32																								1	17
Parachironomus		1		42																							27	
Djalmabatista		1																							18		1	
Xenochironomus			33	42																								
Robackia																								2				
Hydrobaenus																								2				
Stempellinella																		4		25			76	2				
Symposiocladius								27																				
Psectrotanypus																											26	

(Continued)

(Sheet 4 of 5)

Table B1. Concluded

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
MOLLUSCA																												
GASTROPODA																												
<u>Juga</u>																	33	184	64	52	221	10	412	69				
Hydrobiidae																												
<u>Pluminicola</u>							2		32	49	8	6					61	90	93	1	204	44	292	75				
Ancylidae																												
<u>Ferrissia</u>	2		6					8									4	11	9									
Planorbidae																												
<u>Gyraulus</u>	-								-								-								-			
<u>Vorticifex</u> (<u>Parapholyx</u>)																			2									
PELECYPODA																												
Margaritiferidae																												
<u>Margaritifera</u>																	1										1	
Corbiculidae																												
<u>Corbicula</u>								5									60	56	8		1	1	5	12				
Sphaeriidae	1	12			30	9	6	17									6	11	59				56	2				
CHORDATA																												
PETROMYZONTES																												
PETROMYZONTIFORMES																												
Petromyzontidae																												
<u>Lampetra</u>	8		2		20		1					1								13			31					
OSTEICHTHES																												
SCORPEANIFORMES																												
Cottidae																												
<u>Cottus</u>							6		1												5		28					
Station Totals — No. Individuals	2814	8976	5293	7724	9438	5647	3121	8922	884	636	772	2420	859	128	395	165	216	1176	483	2200	953	362	6570	342	1445	860	5772	1882
Station Totals — No. Taxa	41	36	36	32	34	28	28	30	14	16	15	31	19	12	18	14	17	31	32	20	25	16	25	29	10	18	28	18
Location Totals — No. Individuals	24,807				27,128				4,712				1,547				4075				8227				9959			
Location Totals — No. Taxa	57				51				39				30				52				46				39			

(Sheet 5 of 5)

Table B2. Numbers by taxa of invertebrates identified from benthic samples taken at 28 locations within seven habitats between river miles 58 and 66 of the Willamette River, Oregon, August, 1982. Dashes (–) in station columns denote invertebrate taxa that were only collected during the June sampling period.

PHYLUM / CLASS / ORDER / Family / Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
PLATYHELMINTHES																												
TURBELLARIA																												58
NEMATODA									2															4		12	12	12
NEMATOMORPHA	9		65	38	81	33	17	27	175	21	50	65	455	33	30	2	14	50	8	33	137	43	45	4	4	12	1	1
ANNELIDA																												
OLIGOCHAETA	1110	1230	1243	728	64	218	275	43	6	8	62	114	37	2	10	1	29	29	4	367	149	94	33	21	862	197	576	420
BRANCHIOBDELLIDA	50	50	12					17															129					
POLYCHATEA																												
Sabellidae																												
Manayunkia speciosa	174	1980	945	995	6	1626	83	75					24					4					2					
HIRUDINEA																												
Erpobdellidae																												
Erpobdella																												19
Dina																						7	5					
Glossiphonidae																												
Placobdella									2																			
Helobdella							6				40	10									4		9	6			292	19
ARTHROPODA																												
CRUSTACEA																												
OSTRACODA																							1			3	12	
ISOPODA																												
Asellidae																												
Asellus																										1	219	562
AMPHIDODA																												
Gammaridae																												
Anisogammarus	382	1383	1186	964	21	498	232	155			1		219	2							29		64	50		1		1
Talitridae																												
Hyalella azteca	25		25	12																				2			9	130
DECAPODA																												
Astacidae																												
Pacifastacus leniusculus	8	8	6	4		3	3	2					1										1					
ARACHNOIDEA																												
HYDRACARINA																												
Lebertiidae																												
Lebertia				12	2	17	11			8	10	65	12	12	4	1	7	4		5		92	5					
Torrenticolidae																												
Torrenticola																	7											
Arrenuridae																												
Arrenurus																											58	22
Mideopsidae																												
Mideopsis																			4	5			2					22

(Continued)

(Sheet 1 of 5)

Table B2. Continued

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Unionicolidae																												
Unionicola																									97	25	58	67
Pionidae																												
Forelia																												20
Piona																									24		39	
Sperchonidae																												
Sperchon	2										10			4														
Aturidae		12				8																						
Aturus	-								-								-								-			
Hygrobatidae																												
Hygrobates											10																	
Atractides																						7						
Anystidae																												
Anystis	-								-								-								-			
INSECTA																												
COLLEMBOLA																												
Isotomidae																										1		
PLECOPTERA																												
Nemouridae																												
Zapada	-								-								-								-			
Perlidae																												
Claassenia	-								-								-								-			
EPHEMEROPTERA																												
Leptophlebiidae																												
Paraleptophlebia	8						6																					
Ephemeridae																												
Hexagenia	-								-								-								-			
Serratella											20																	
Tricorythidae																												
Tricorythodes	8		12			17	6	6	12	21	81	100	24	19	14	1		4			8	199	2					
Caenidae																												
Caenis																											25	38
Ephemerellidae																												
Ephemerella																								1				
Heptageniidae																												
Epeorus	-								-								-								-			
Rhithrogena											10													17				
Stenonema	8	25	12			33	11	12			21	25	219		3		15				4	7	26	7				
Heptagenia		12									6												2					
Baetidae																												
Centroptilum		12	37	50	2		6		5																			
Baetis		-							-								-								-			
Pseudocloeon									2	12	119	10			2			2							17			

(Continued)

(Sheet 2 of 5)

Table B2. Continued

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
ODONATA																												
Coenagriidae																											13	38
Ischnura	-								-								-								-			
HOMOPTERA																												1
MEGALOPTERA																												
Sialidae																												
Sialis																									1	4	3	5
NEUROPTERA																												
Sisyridae																												
Sisyra	-								-								-								-			
Climacia																1												
TRICOPTERA (pupae)						1			7	21							63	2			2			2				2
Hydropsychidae																												
Hydropsyche										4	30			12	6					5	4		2	108				
Cheumatopsyche	8					17		6		12	40	10	24	19	13	1	26				25	21	7	30				
Hydroptilidae																												
Leucotrichia						8																						
Hydroptila	17	24			2	8	12	2	2													43						
Leptoceridae																												
Oecetis																											39	88
Ceraclea	415	597	137	249	19	574	156	79		8		5	24	19	11		28	4			17	21	21					
Glossosomatidae																												
Glossosoma										41	20	15					53	10				7		132				
Protoptila										8														31				
Psychomyiidae																												
Psychomyia	25	37		24	15	108	6	27	2	4		15																
Polycentropodidae																												
Polycentropus			1																									
Brachycentridae																												
Brachycentrus													1															
Lemnephilidae																												
Dicosmoecus	-								-								-								-			
LEPIDOPTERA																												
Pyralidae																												
Parargyractis	16	379	64	77	12	84	69	25		37	10	35																
COLEOPTERA																												
Elmidae																												
Dubiraphia (larvae)																				5					12	43	297	371
Dubiraphia (adult)																											1	29
Optioservus (larvae)																						14						
DIPTERA																												
Tipulidae (pupae)												10																
Antocha (larvae)				12	4	17		2		4	30	20			1													
Chaoboridae																									1		1	

(Continued)

Table B2. Continued

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Simuliidae (pupae)													12									14		5				
Simulium (larvae)												10			1		2							22				
Empididae																												
Hemerodromia (larvae)										25	72				1							7						
Hemerodromia (pupae)										4																		
Ephydridae (larvae)	-								-								-								-			
Ceratopegonidae																												
Bezzia-Probezzia	-								-								-								-			
Palpomyia	8									8					20			10				57		8				
Chironomidae (pupae)		62	51	112		33	34	35	10	12	190	85	12	12	25	1				9	4	7	7			1	25	60
Rheotanytarsus	25	154	18	110	2	61	17	6	4	72	773	48	36				7			5		24	5	2				
Cricotopus		38	73	28						24	55	63	12															
Eukiefferiella		77		83	2			17	12	120	663	79					7											
Synorthocladius	8	1		55	2	15			8		276	32					7	8			4	48				12		
Paratanytarsus	8	38	55	28	2	30																	1		12			
Orthocladius-Cricotopus	101	1352	367	744	15	439	25	145	22	228	607	492	158	148	188	3		4		14		24	2	2	1	12		
Endochironomus	76		18	28	42	15	1	6	23						5						4			2		12		
Dicrotendipes	101	77	201	28	4	60	1	45	8					6	5	1				5		8					223	12
Nanocladius	34	38	55	55																								
Stenochironomus						1		6																				
Tanytarsus	25	38	18			15			4											24		8		2			133	62
Polypedilum	17	271	37	240	17	122		61	35	144	442	16	170	161	54	3	36	4	8	32	25	8	2	26				58
Chironomus	8				11			6	34										4	34				4	73	43	133	94
Thienemanniella	17																					8						19
Procladius					2								12				14	2		18				2	2	135	1254	1089
Micropsectra																												12
Paracladopelma					4			11	24										4	77	17		2	2				
Cryptochironomus	17				2				19	12		32	24			1			4	46	12		5			49	50	12
Potthastia													24															
Cladopelma																										39	542	310
Ablabesmyia																												24
Parachironomus	17		18		2																						58	19
Djalmabatista																										1		
Xenochironomus			73																									
Pentaneura														6														
Stictochironomus					2																							
Glyptotendipes																												38
Kiefferulus																				9								
Paralauterborniella																			4	5								

(Continued)

Table B2. Concluded

PHYLUM CLASS ORDER Family Genus, species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
MOLLUSCA																												
GASTROPODA																												
<u>Juga</u>	8					8	33	4	12	18	10	35			68		646	54	49	55	242	1090	88	24				
Hydrobiidae																												
<u>Fluminicola</u>	17				6			1	70	485	893	141	1	2	10		1435	400	36	121	641	837	294	148		1	12	19
Ancylidae																												
<u>Ferrissia</u>		75	62	37		17		4															2	2				
Planorbidae																												
<u>Gyraulus</u>																												
<u>Vorticifex</u> (<u>Parapholyx</u>)																	14					7						77
PELECYPODA																												
Margaritiferidae																												
<u>Margaritifera</u>																				1								1
Corbiculidae																												
<u>Corbicula</u>						1		6			1		2				8	19	6	1	1	6	2					1
Sphaeriidae		12		12	6			6		4			61	6	22			8		875	141	301	60		12			231
CHORDATA																												
PETROMYZONTES																												
PETROMYZONTIFORMES																												
Petromuyzontidae																												
<u>Lampetra</u> (<u>ammocoete</u>)		1			1								1															
OSTEICHTHYES																												
SCORPAENIFORMES																												
Cottidae																												
<u>Cottus</u>													1															
Station Totals: No. Individuals	2752	7983	4791	4727	354	4087	1010	837	500	1365	4552	1532	1566	463	493	16	2416	618	131	1751	1470	3009	826	666	1118	604	4085	4063
Station Totals: No. Taxa	32	26	25	24	28	28	19	28	23	24	28	23	24	15	20	10	18	17	11	22	18	27	28	25	13	19	24	36
Location Totals: No. Individuals	20,253				6288				7949				2538				4916				5971				9870			
Location Totals: No. Taxa	44				42				43				36				35				47				47			

(Sheet 5 of 5)

APPENDIX C: SEDIMENT SAMPLE ANALYSES

SEDIMENT SAMPLES RECEIVED FOR LABORATORY ANALYSIS[1]

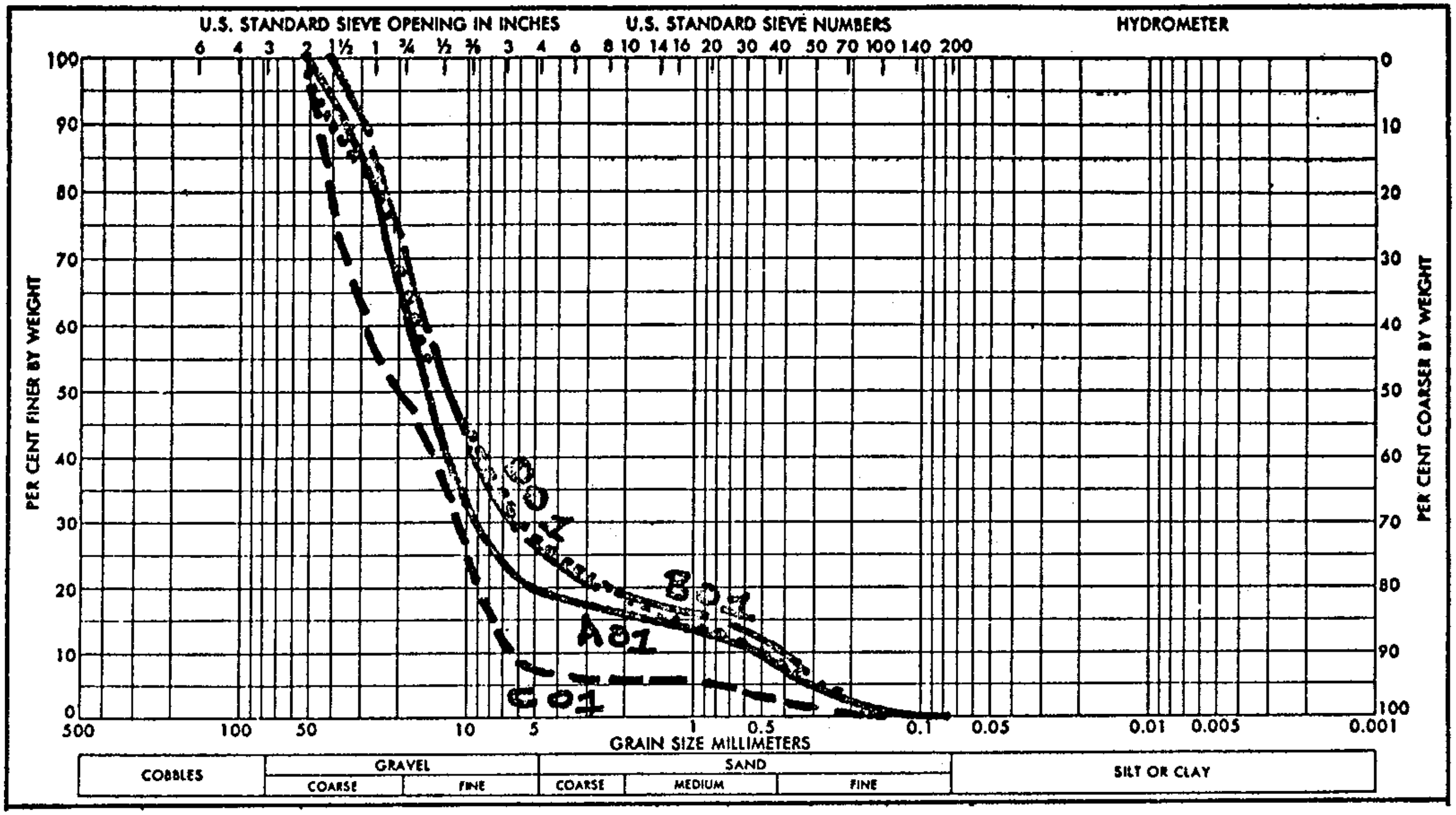
Sampling Location	Approx. RM	Sampling Station	Sampling Date	Sampling Time	Sampling Method	Field I.D. No.	Lab. I.D. No.	Computer Loc. Code
Candiani Side Channel	58.5	(A01)	6/15/82	1030	dredge	05	3	PCC
		B01	6/15/82	1130	scoop/bag	07	4	
		C01	6/15/82	1300	scoop/bag	09	1	
		D01	6/15/82	(1430)	scoop/bag	11	2	
Candiani Main Channel	58.5				(See note 2) #14, 6/16/82		14,17,18	NBC
		D01	6/16/82	0900	(scoop/bag)	13	13	
Five Island Main Channel	62	A01	6/16/82	1325	scoop/bag	21	20	NBF
		B01	6/16/82	1400	scoop/bag	23	15	
		C01	6/16/82	1540	scoop/bag	25	16	
		D01	6/16/82	1705	scoop/bag	27	19	
Five Island Secondary Channel	62	A01	6/17/82	1330	scoop/bag	34	9	PCF
		B01	6/17/82	(1400)	scoop/bag	36	11	
		C01	(6/17/82)	(1220)	(scoop/bag)	32	12	
		D01	6/17/82	--	---	(30)	10	
Lambert Slough	65	A01	6/18/82	(1015)	scoop/bag	44	7	ABS
		B01	6/18/82	0900	scoop/bag	42	8	
		C01	6/17/82	1715	scoop/bag	40	6	
		D01	6/17/82	(1555)	dredge	38	5	

[1] Information tabulated was taken from sample tag (except for river mile (RM) and computer location code) unless shown in parantheses.

[2] For lab samples 14, 17, 18 the field sample tags were not readable (they had broken in small pieces).

SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, FIVE ISLAND MAIN CHANNEL NEAR RM 62

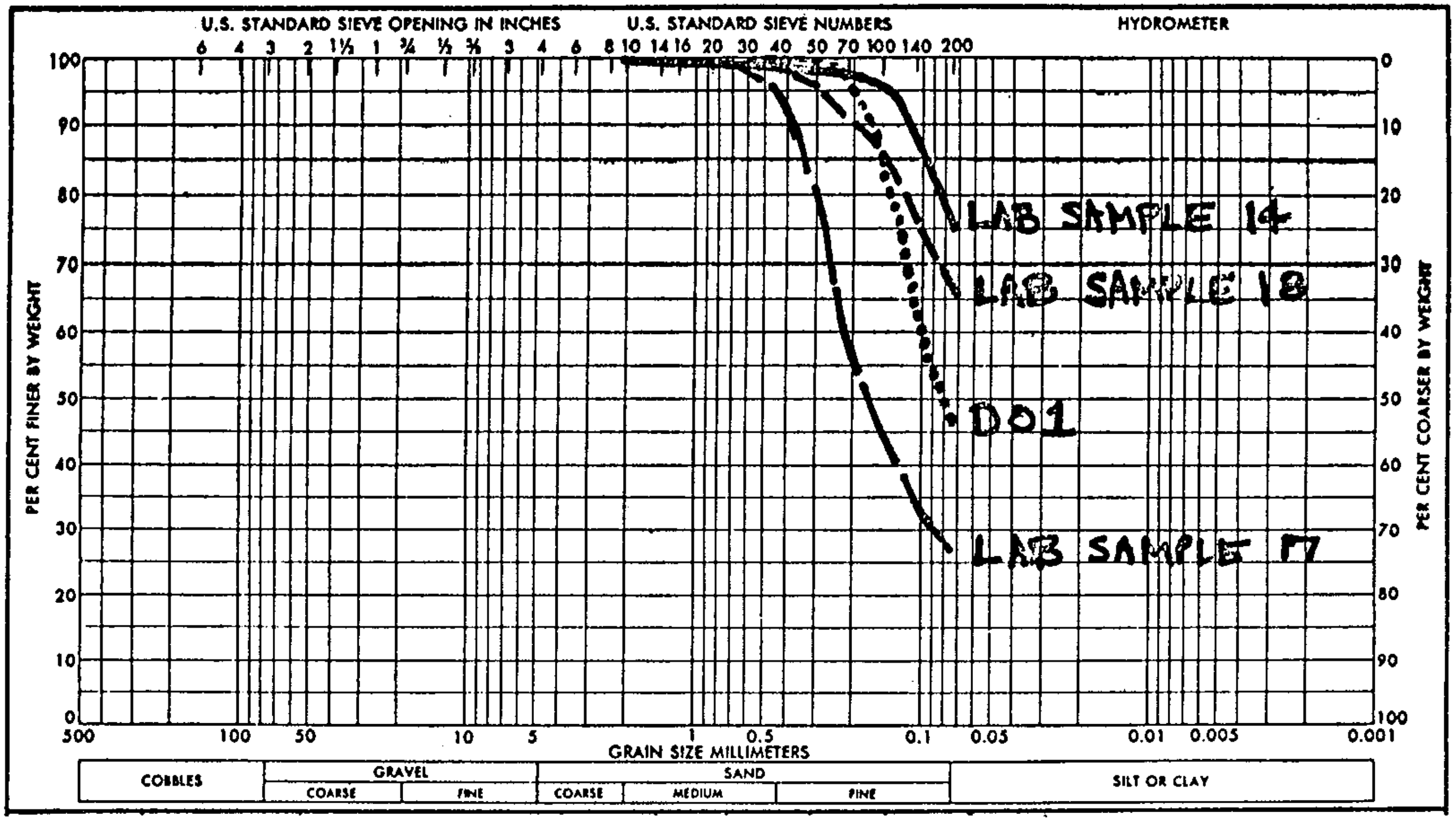
U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	--	--	--
2-in.	0	0	100.0	--	--	--	0	0	100.0	0	0	100.0
1-1/2-in.	91.8	8.78	91.2	0	0	100.0	217.8	23.27	76.7	111.0	10.28	89.7
1-in.	99.0	9.48	81.7	147.2	14.31	85.7	182.2	19.48	57.3	100.8	9.33	80.4
3/4-in.	194.8	18.64	63.1	154.8	15.04	70.7	69.8	7.45	49.8	174.5	16.16	64.2
1/2-in.	203.0	19.43	43.7	204.0	19.82	50.8	111.2	11.89	37.9	169.0	15.65	48.6
3/8-in.	122.0	11.68	32.0	107.5	10.44	40.4	134.8	14.40	23.5	76.0	7.04	41.5
No. 3	94.2	9.02	23.0	107.5	10.44	30.0	123.0	13.14	10.4	113.5	10.51	31.0
No. 4	32.2	3.09	19.9	47.2	4.59	25.4	28.2	3.02	7.4	47.8	4.42	26.6
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	40.5	3.88	16.0	57.0	5.54	19.8	11.0	1.18	6.2	77.0	7.13	19.5
No. 10	6.8	0.65	15.4	11.0	1.07	18.8	0.8	0.08	6.1	20.2	1.88	17.6
No. 16	12.0	1.15	14.2	18.0	1.75	17.0	1.5	0.16	5.9	31.0	2.87	14.7
No. 20	11.8	1.12	13.1	8.8	0.85	16.2	1.5	0.16	5.8	16.5	1.53	13.2
No. 30	19.8	1.89	11.2	15.2	1.48	14.7	9.0	0.96	4.8	19.0	1.76	11.4
No. 40	28.2	2.70	8.5	38.2	3.72	11.0	16.2	1.74	3.1	29.5	2.73	8.7
No. 50	36.2	3.47	5.0	56.5	5.49	5.5	12.5	1.34	1.7	39.5	3.66	5.1
No. 70	24.8	2.37	2.7	31.2	3.04	2.4	8.0	0.85	0.9	29.8	2.76	2.3
No. 100	18.0	1.72	0.9	18.0	1.75	0.7	5.5	0.59	0.3	18.2	1.69	0.6
No. 140	5.5	0.53	0.4	5.2	0.51	0.2	1.5	0.16	0.1	4.8	0.44	0.2
No. 200	1.8	0.17	0.2	1.2	0.12	0.1	0.8	0.08	0.1	1.2	0.12	0.1
Pan	2.5	0.24	0.0	0.5	0.05	0.0	0.5	0.05	0.0	0.5	0.05	0.0
Total Weight, grams	1044.8	--	--	1029.2	--	--	935.8	--	--	1079.8	--	--



GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,
FIVE ISLAND MAIN CHANNEL NEAR RM 62

SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, CANDIANI MAIN CHANNEL NEAR RM 58.5

U.S. Standard Sieve Size or Number	LAB SAMPLE 14			LAB SAMPLE 17			LAB SAMPLE 18			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	--	--	--
2-in.	--	--	--	--	--	--	--	--	--	--	--	--
1-1/2-in.	--	--	--	--	--	--	--	--	--	--	--	--
1-in.	--	--	--	--	--	--	--	--	--	--	--	--
3/4-in.	--	--	--	--	--	--	--	--	--	--	--	--
1/2-in.	--	--	--	--	--	--	--	--	--	--	--	--
3/8-in.	--	--	--	--	--	--	--	--	--	--	--	--
No. 3	--	--	--	--	--	--	--	--	--	--	--	--
No. 4	--	--	--	--	--	--	--	--	--	--	--	--
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	--	--	--	--	--	--	--	--	--	--	--	--
No. 10	0	0	100.0	0	0	100.0	--	--	--	--	--	--
No. 16	0.2	0.09	99.9	0.8	0.08	99.9	--	--	--	--	--	--
No. 20	0.5	0.18	99.7	2.5	0.25	99.7	0	0	100.0	--	--	--
No. 30	0.8	0.27	99.5	10.2	1.03	98.6	0.8	0.19	99.8	0	0	100.0
No. 40	0.8	0.27	99.2	40.2	4.03	94.6	2.8	0.69	99.1	1.0	0.10	99.9
No. 50	1.5	0.53	98.7	165.0	16.53	78.1	15.5	3.88	95.2	6.5	0.63	99.3
No. 70	1.2	0.44	98.2	202.0	20.74	57.8	16.0	4.01	91.2	22.5	2.18	97.1
No. 100	4.5	1.59	96.6	116.8	11.70	46.2	17.2	4.32	86.9	125.0	12.13	85.0
No. 140	20.5	7.24	89.4	125.2	12.55	33.6	35.2	8.83	78.1	224.0	21.74	63.2
No. 200	41.2	14.58	74.8	60.0	6.01	27.6	51.8	12.97	65.1	169.5	16.45	46.8
Pan	211.8	74.82	0.0	275.5	27.60	0.0	259.8	65.10	0.0	482.0	46.77	0.0
Total Weight, grams	283.00	--	--	998.2	--	--	399.0	--	--	1030.5	--	--

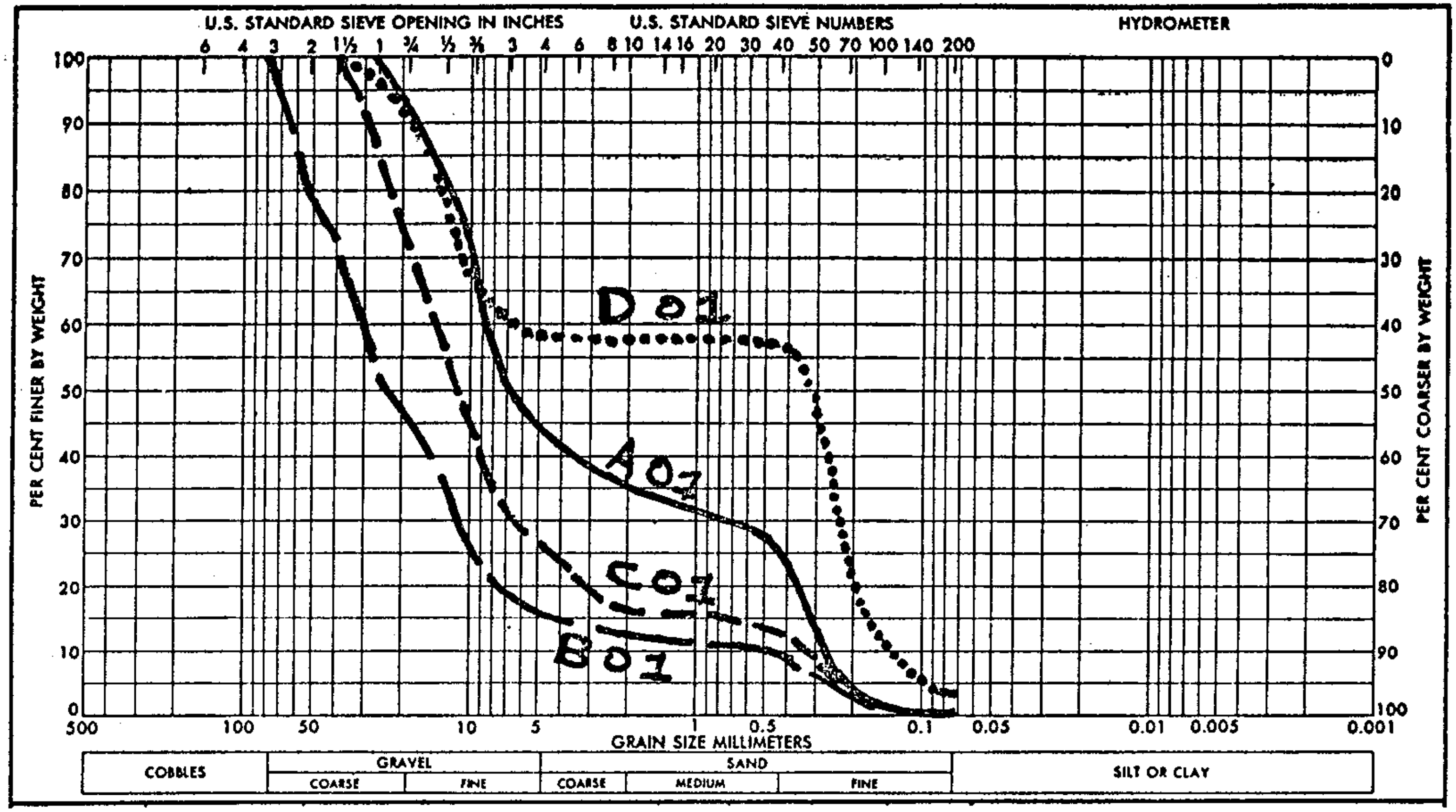


GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,

CANDIANI MAIN CHANNEL NEAR RM 58.5

SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, FIVE ISLAND SECONDARY CHANNEL NEAR RM 62

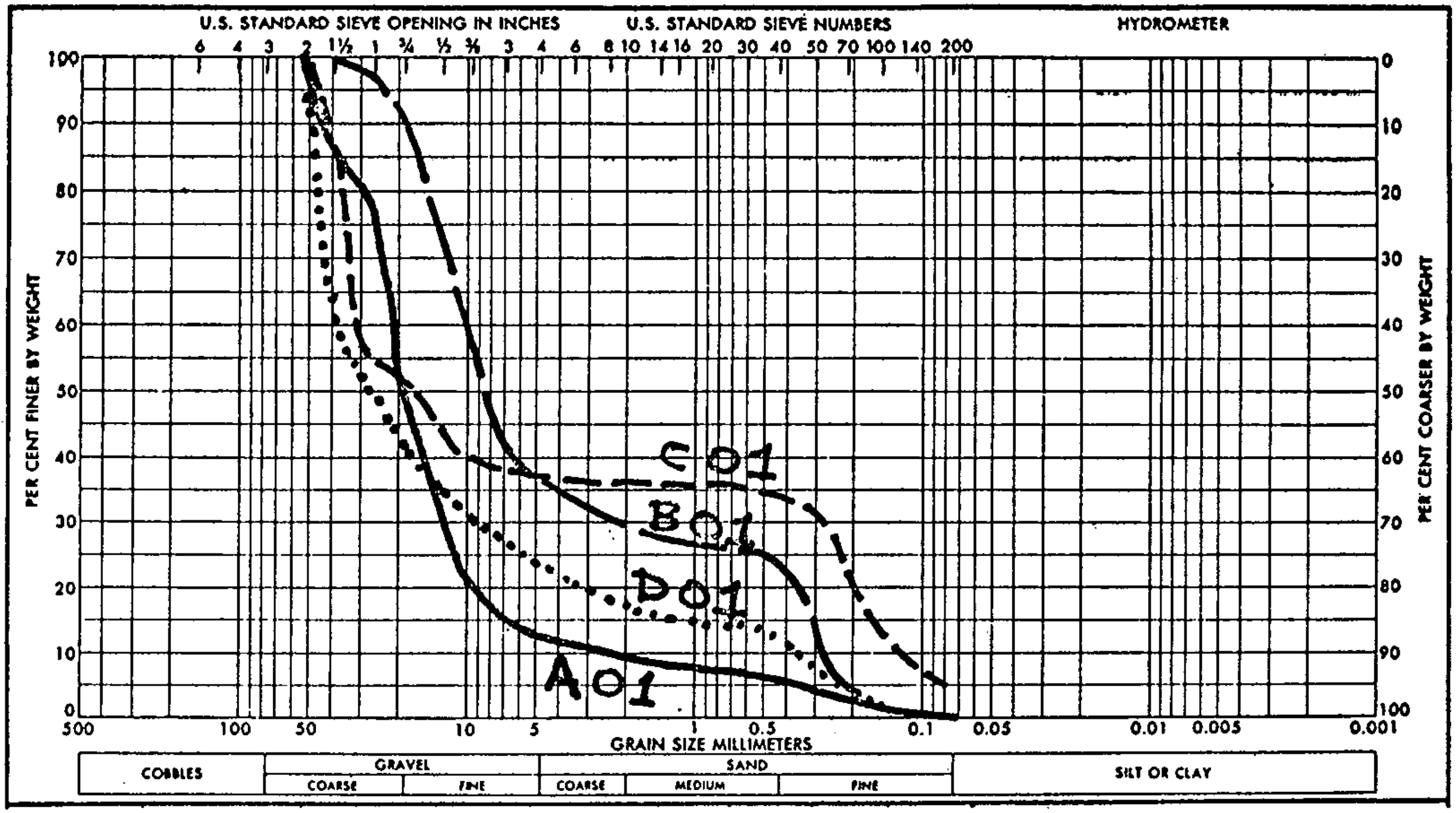
U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	0	0	100.0	--	--	--	--	--	--
2-in.	--	--	--	299.0	20.08	79.9	--	--	--	--	--	--
1-1/2-in.	--	--	--	92.0	6.18	73.7	0	0	100.0	0	0	100.0
1-in.	0	0	100.0	307.8	20.66	53.1	214.0	11.95	88.1	33.5	3.14	96.9
3/4-in.	78.0	7.93	92.1	88.0	5.91	47.2	261.0	14.57	73.5	54.0	5.07	91.8
1/2-in.	97.5	9.91	82.2	165.0	11.08	36.1	305.8	17.07	56.4	151.5	14.22	77.6
3/8-in.	162.2	16.49	65.7	145.2	9.75	26.3	262.8	14.67	41.7	113.0	10.60	67.0
No. 3	149.5	15.20	50.5	120.8	8.11	18.2	196.2	10.96	30.8	71.8	6.73	60.2
No. 4	68.0	6.91	43.6	42.8	2.87	15.4	73.0	4.08	26.7	18.2	1.71	58.5
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	71.0	7.22	36.3	32.2	2.17	13.2	176.5	9.85	16.9	6.8	0.63	57.9
No. 10	14.0	1.42	34.9	4.5	0.30	12.9	9.0	0.50	16.4	0.0	0.00	57.9
No. 16	29.5	3.00	31.9	10.8	0.72	12.2	13.0	0.73	15.6	0.2	0.02	57.9
No. 20	6.5	0.66	31.3	7.5	0.50	11.7	5.5	0.31	15.3	0.0	0.00	57.9
No. 30	17.0	1.73	29.5	10.0	0.67	11.0	10.8	0.60	14.7	0.5	0.05	57.8
No. 40	30.5	3.10	26.4	17.8	1.19	9.8	25.2	1.41	13.3	6.0	0.56	57.3
No. 50	114.5	11.64	14.8	44.0	2.95	6.9	74.0	4.13	9.2	89.5	8.40	48.9
No. 70	93.2	9.48	5.3	46.2	3.11	3.8	77.2	4.31	4.9	234.8	22.03	26.8
No. 100	39.5	4.02	1.3	35.0	2.35	1.4	53.0	2.96	1.9	151.8	14.24	12.6
No. 140	8.5	0.86	0.4	11.8	0.79	0.6	20.2	1.13	0.8	69.0	6.47	6.1
No. 200	1.8	0.18	0.3	4.2	0.29	0.3	8.5	0.47	0.3	28.8	2.70	3.4
Pan	2.5	0.25	0.0	4.8	0.32	0.0	5.5	0.31	0.0	36.5	3.42	0.0
Total Weight, grams	983.8	--	--	1489.2	--	--	1791.2	--	--	1065.8	--	--



GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,
FIVE ISLAND SECONDARY CHANNEL NEAR RM 62

SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, CANDIANI SIDE CHANNEL NEAR RM 58.5

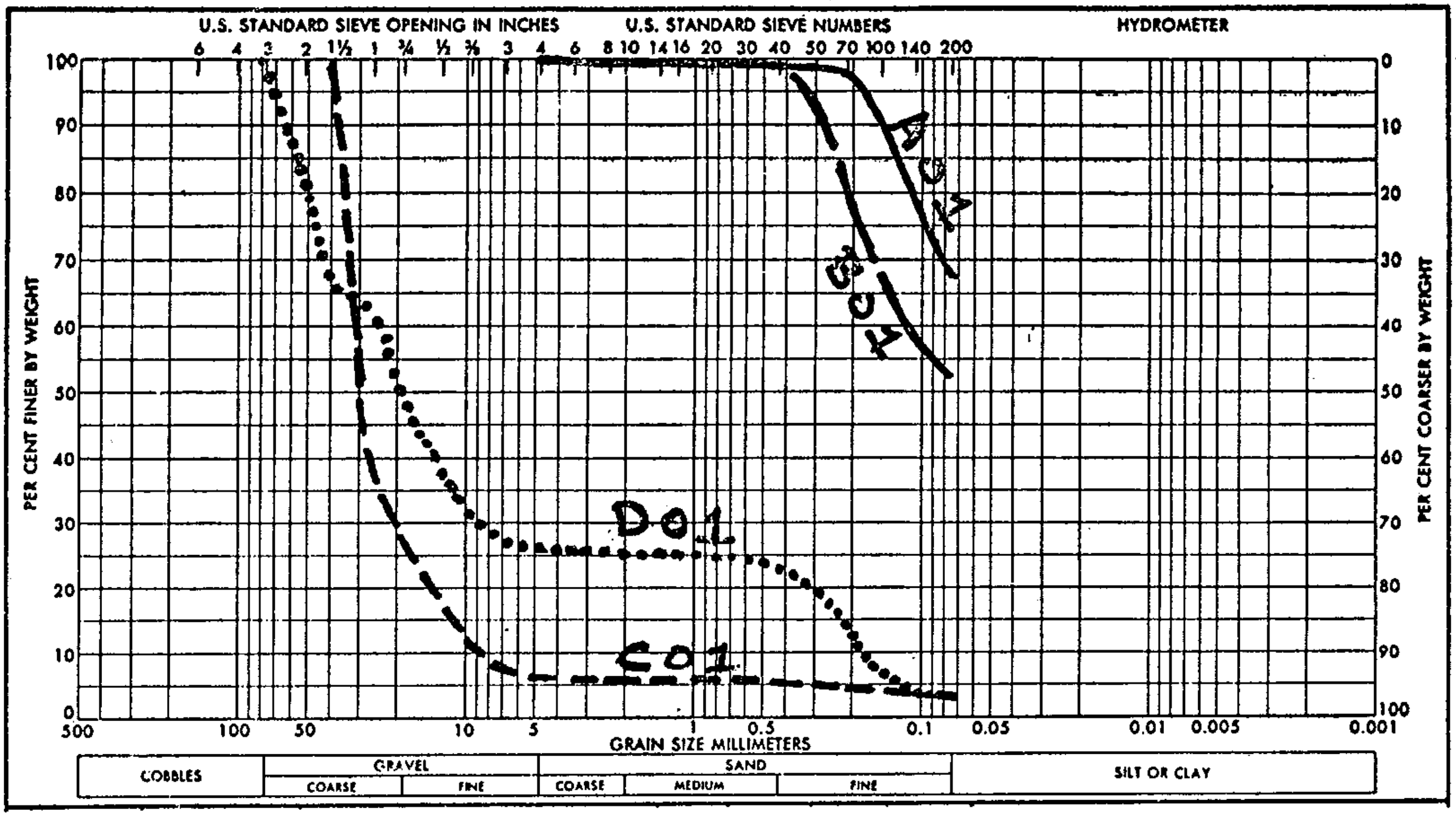
U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	--	--	--
2-in.	0	0	100.0	--	--	--	0	0	100.0	0	0	100.0
1-1/2-in.	237.0	13.99	86.0	0	0	100.0	171.0	12.44	87.6	975.0	39.54	60.5
1-in.	145.0	8.56	77.5	99.5	2.30	97.7	454.0	33.03	54.5	285.5	11.58	48.9
3/4-in.	479.2	28.29	49.2	324.0	7.50	90.2	43.0	3.13	51.4	190.0	7.70	41.2
1/2-in.	314.8	18.58	30.6	806.0	18.67	71.5	132.5	9.64	41.8	137.8	5.59	35.6
3/8-in.	174.0	10.27	20.3	614.0	14.22	57.3	24.5	1.78	40.0	110.8	4.49	31.1
No. 3	85.5	5.05	15.3	670.0	15.52	41.8	27.0	1.96	38.0	134.8	5.46	25.6
No. 4	43.2	2.55	12.7	263.0	6.09	35.7	9.2	0.67	37.3	78.8	3.19	22.5
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	46.5	2.74	10.0	244.0	5.65	30.1	18.0	1.31	36.0	126.0	5.11	17.3
No. 10	8.5	0.50	9.5	37.0	0.86	29.2	5.5	0.40	35.6	19.2	0.78	16.6
No. 16	12.5	0.74	8.7	42.5	0.98	28.2	6.5	0.47	35.2	37.0	1.50	15.1
No. 20	6.0	0.35	8.4	15.0	0.35	27.9	1.5	0.11	35.1	13.5	0.55	14.5
No. 30	10.0	0.59	7.8	25.0	0.58	27.3	0.8	0.05	35.0	11.8	0.48	14.0
No. 40	15.2	0.90	6.9	151.5	3.51	23.8	1.0	0.07	34.9	27.2	1.11	12.9
No. 50	33.5	1.98	4.9	549.0	12.71	11.1	28.2	2.06	32.9	122.0	4.95	8.0
No. 70	39.2	2.32	2.6	280.5	6.50	4.6	98.8	7.18	25.7	119.2	4.84	3.1
No. 100	27.0	1.59	1.0	146.0	3.38	1.2	150.8	10.97	14.7	58.8	2.38	0.8
No. 140	8.8	0.52	0.5	35.0	0.81	0.4	90.8	6.60	8.1	13.5	0.55	0.2
No. 200	3.8	0.22	0.3	7.5	0.17	0.2	50.0	3.64	4.5	2.8	0.11	0.1
Pan	4.5	0.27	0.0	8.5	0.20	0.0	61.5	4.47	0.0	2.5	0.10	0.0
Total Weight, grams	1694.2	--	--	4318.0	--	--	1374.5	--	--	2466.0	--	--



GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,
CANDIANI SIDE CHANNEL NEAR RM 58.5

SIEVE ANALYSIS, SEDIMENTS SAMPLES FROM WILLAMETTE RIVER, LAMBERT SLOUGH NEAR RM 65

U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	0	0	100.0
2-in.	--	--	--	--	--	--	--	--	--	434.0	18.27	81.7
1-1/2-in.	--	--	--	--	--	--	0	0	100.0	381.0	16.04	65.7
1-in.	--	--	--	--	--	--	660.5	58.66	41.3	36.2	1.53	64.2
3/4-in.	--	--	--	--	--	--	182.0	16.16	25.2	308.0	12.96	51.2
1/2-in.	--	--	--	--	--	--	91.0	8.08	17.1	272.0	11.45	39.8
3/8-in.	--	--	--	--	--	--	79.0	7.02	10.1	187.8	7.90	31.9
No. 3	--	--	--	--	--	--	35.2	3.13	7.0	92.0	3.87	28.0
No. 4	0	0	100.0	--	--	--	10.2	0.91	6.0	28.2	1.19	26.8
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	0.2	0.05	99.9	--	--	--	6.0	0.53	5.5	22.2	0.94	25.9
No. 10	0.0	0	99.9	--	--	--	0.2	0.02	5.5	5.2	0.22	25.6
No. 16	0.2	0.05	99.9	--	--	--	1.0	0.09	5.4	8.5	0.36	25.3
No. 20	0.2	0.05	99.8	--	--	--	0.5	0.04	5.4	4.5	0.19	25.1
No. 30	0.0	0.00	99.8	0	0	100.0	0.2	0.02	5.3	0.8	0.03	25.1
No. 40	0.0	0.00	99.8	2.0	0.26	99.7	1.8	0.16	5.2	30.8	1.29	23.8
No. 50	0.2	0.05	99.8	43.2	5.56	94.2	4.5	0.40	4.8	77.8	3.27	20.5
No. 70	4.2	0.92	98.9	94.0	12.07	82.1	3.2	0.29	4.5	142.8	6.01	14.5
No. 100	35.0	7.62	91.2	112.2	14.42	67.7	5.0	0.44	4.0	159.0	6.69	7.8
No. 140	63.0	13.71	77.5	75.5	9.70	58.0	5.5	0.49	3.6	73.8	3.10	4.7
No. 200	48.2	10.50	67.0	46.5	5.97	52.0	6.5	0.58	3.0	29.2	1.23	3.5
Pan	308.0	67.03	0.0	405.0	52.02	0.0	33.5	2.98	0.0	82.2	3.46	0.0
Total Weight, grams	459.5	--	--	778.5	--	--	1126.0	--	--	2376.0	--	--



GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,
LAMBERT SLOUGH NEAR RM 65